SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

MARCH 1898.

GENERAL PHYSICS.

231. *Automatic Mercury Pump.* **F. Friedrichs.** (Annal. Phys. Chem. 62. pp. 383–384, 1897.)—This is Kahlbaum's modification of the Sprengel pump provided with an apparatus for automatically cleaning and drying the mercury in its passage.

E. E. F.

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232. *Surface Tension.* **N. E. Dorsey.** (Phys. Rev. 5. pp. 213–230, 1897.)—This paper is a continuation of an earlier one (see Phys. Soc. Abstracts, No. 688, Dec. 1897). The surface-tension of water at 18° C. is 73·32 dynes per cm. The surface-tension of certain *dilute* solutions is given by the formula $T_s = T_w + KC$, where T_s is the surface-tension of water containing *c* gram-equivalents per litre, T_w is the surface-tension of water at the same temperature, and K is a constant. At 18° C., for NaCl, KCl, $\frac{1}{2}(Na_2CO_3)$, $\frac{1}{2}(K_2CO_3)$, and $\frac{1}{2}(ZnSO_4)$, K equals 1·53, 1·71, 2·00, 1·77, and 1·86 respectively.

A. Gs.

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233. *Measurement of Air-films.* **C. Fabry** and **A. Perot.** (Annal. Chim. Phys. 12. pp. 459–501, 1897).—The necessity for the measurement of thin air-films was introduced in connection with experiments by the authors on electrometers in which the distance between two surfaces had to be obtained. The present paper describes the method adopted, and also contains a general consideration of the interference fringes produced when light passes through a thin air-film between two semi-silvered glass surfaces. The silvering of the glass increases the reflecting power of the surfaces, and makes the fringes much sharper and narrower than is the case when ordinary glass surfaces are used. If the

air-film is not of uniform thickness and a beam of monochromatic light be sent through it, then wherever the thickness of the film is a multiple of the wave-length a bright band is observed, the form of the bands depending on the shape of the surfaces. If the light is not monochromatic, then coloured bands are observed; and if the air-film is wedge-shaped in form with perfectly plane sides, the bands are parallel and equally spaced, the thickness of the film increasing by one wave-length between two successive bands of the same colour. It is evident that if the thickness of the film in wave-lengths could be determined at any one point of such a prism, then at any other point it would also be known in terms of the same wave-length.

When the light used contains only two wave-lengths, two systems of bands are produced which coincide the one with the other at regular intervals, the intervals being smaller the greater the difference between the wave-lengths. By employing such light an easy means of counting the fringes is provided. When two films are superposed by placing one behind the other, or, better, by placing one at the optical image of the other by means of a lens, and a beam of parallel white light is sent normally through them, then, wherever the thicknesses of the two films are equal or bear a simple ratio to each other, Brewster's white bands are observed, the intensity of the band being greatest for equality of thickness, and decreasing as the ratio of the thicknesses becomes less simple. Between these white bands coloured interference-bands are observed, due to difference of thickness of the two films.

To find the thickness of any thin film of air, it is sufficient to superpose it optically on a standard wedge-shaped film and find by means of the bands in white light where the thicknesses of the two are equal.

This standard can be made of two lightly silvered strips of glass placed face to face with pieces of tin-foil of different thicknesses between the ends, a mm. scale being engraved along one of the strips. The interference-fringes observed when the standard is viewed in sodium light enable one to calibrate the mm. scale in wave-lengths of this light, provided the thickness of the film is known at one point. To obtain this, let us suppose the film varies in thickness from about 100 wave-lengths at the one end to 300 at the other. Make another film approximately about 120 wave-lengths in thickness; then, by superposing this on the standard, find the points where the latter has the same and also double the thickness of the former. Knowing the number of sodium bands which occur between these two points on the standard, one obtains at once the thickness of the standard film at the first point. J. B. H.

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234. *Protection of Instruments from Vibration.* **A. Broca.** (Écl. Électr. 13. pp. 581–583, 1897.)—The author points out that in the case of instruments such as galvanometers in which

the movable parts are very light, no advantage is obtained by supporting the instrument on rubber blocks, but that in this case the instrument ought to be suspended by strings. With instruments in which the part which has to be preserved from tremors is massive, on the other hand, rubber blocks are of use. W. W.

235. *The Distribution of Mass in the Earth.* **E. Wiechert.** (Göttingen Nachrichten, 3. pp. 221–243, 1897.)—As the mean density of the earth is about 5·6, that of the materials of the surface averaging 3, and as the substances of greater density than 5·6 are almost all metals, Wiechert assumes that the earth has a metallic interior and that the change in density will be abrupt. To simplify his calculations, he supposes that the metallic core has one uniform density, and the shell another. He starts from the hypothesis of hydrostatic equilibrium, that core and shell would be limited by gravitational levels. Various considerations lead him to assign a density of 7·8, that of compressed iron, to the metallic core. As the pendulum on the whole is little influenced by the relief of the surface, and as layers, several kilometres in thickness, have been transposed in the course of time, he further accepts the supposition that the surface-crust is borne by a layer of materials in the fused state. That layer cannot be thick because earthquake waves appear to be propagated along the surface, and the earth as a whole behaves, as regards the tides, like a body with the rigidity of steel. In round numbers the core would have a radius of 5000 km., the shell a radius of 1400 km. (between 1200 and 1600 km.): the shell and core would be about equal in volume, and the ratio of their masses would be 2 : 5. The geoid seems to deviate little from an ellipsoid. Whether or not there be hydrostatic equilibrium is investigated by comparing the values for the aplanatism of the earth as deduced from geodetic measurements, variations of g, and disturbances of the moon's orbit, with those deduced from nutation and precession. The comparison seems to indicate that the core is slightly less flattened than would correspond to the present velocity of rotation. H. B.

236. *Velocity of Outflow of Gases and Steam.* **H. Parenty.** (Annal. Chim. Phys. 8. pp. 1–79, 1896, and 12. pp. 289–378, 1897.)—These two papers contain an account of the author's work during the last twelve years, on the outflow of gases through orifices of different shapes. The subject was left by Hirn in an unsatisfactory state, as his experimental data went beyond the theory that existed to account for them. Parenty has succeeded in giving a satisfactory reduction of Hirn's experiments, and has added new data of his own. The elementary theory assumes that when a gas flows out through a narrow orifice from a chamber of higher to one of lower pressure, that the phenomenon is

adiabatic. This leads to the conclusion that the velocity of outflow

$$U=\sqrt{2gECT_0(1-\rho_1{}^{\gamma})},$$

where $E=$ dynamical equivalent; $C=$ specific heat at constant pressure; T_0=absolute temperature of the gas in the reservoir; $\rho_1=p_1/p_0$, where p_0 is the pressure in the reservoir, p_1 the (variable) pressure at the point considered: $\gamma=1-c/C$, where c=specific heat at constant volume. The pressures are given in gravity units (tons per sq. m.). The volume of outflow, expressed in terms of the density of the reservoir, is

$$V_0=m_0m_1S\rho_1{}^{1-\gamma}U_1,$$

where S is the cross section of the orifices, and $m_0\,m_1$ numerical coefficients, so that m_0m_1S is the area of the so-called *vena contracta.*

The result of experiments can be expressed by means of this formula, but with considerable variation in the coefficients $m_0\,m_1$ according to the pressures: provided ρ_1 does not fall below a certain value. But if the pressure in the recipient falls to a certain fraction of p_0, the velocity of the gas at the neck of the stream (which may be in front or behind the actual orifice) rises to that of sound in gas at the temperature of the neck. The fraction (a function of the specific heats) is 0·526 for most gases. Below this no reduction of pressure in the receiver makes any difference to the velocity of outflow, which has reached its limit.

Parenty finds that the observations on the volume of outflow can be more satisfactorily represented by an elliptic formula

$$V_0=\sqrt{2a}\,m_1S\,\sqrt{2gE(C-c)T_0}\,\sqrt{R_1-mR_1{}^2/2a},$$

where $R_1=1-\rho_1=1-p_1/p_0$, $a=0{\cdot}474$=limiting value of R_1 (as above), whilst m_1, the only arbitrary quantity remaining in the equation, is practically the same as the observed coefficient of contraction for liquid jets flowing from the same orifice. If the results are expressed graphically, taking R for abscissa and V_0 for ordinate, the curve is a quadrant of ellipse starting from the origin, with major axis vertical, and situate at $R_1=a$; beyond that value of R_1 the curve is continued by its (horizontal) tangent. The corresponding curve of velocities in the neck is a sinusoid starting from the origin concave to the axis of x and reaching a point of inflexion for $R_1=a$, where the velocity becomes equal to that of sound.

Beyond the neck the jet spreads out again, and the gas possesses a velocity which for some distance is sensibly equal to that at the neck. The distribution of pressure and velocity in this section of the jet was the subject of special experiments, described in the second of the two papers. For this purpose the jet was "sounded" by means of glass tubes, drawn out to a point at one end, the other being connected to a manometer. The tubes were mounted on a sort of slide-rest, which allowed of their being placed at a measured distance in front of an orifice fed by a steam-boiler, either in the axis of the jet or to one side of it. Three tubes were used, one pointing directly at the jet, the second with the point turned round 180°, the third with the point at 90° from the stem. By means of these the apparent pressure, both backwards and forwards, in the direction of the axis, and in both senses of a direction perpendicular to the axis, could be measured; the mean giving the actual pressure, apart from the effects of molar velocity, at each point. The results obtained for two orifices—one convergent, the other so-called contracted—are shown by means of diagrams of the kind used in topography.

The results are complicated; some of the most interesting points being as follows:—At a distance of about two diameters from the orifice the pressure is observed to have the value corresponding to $R_1=a$, *i. e.* the limiting value below which a reduction in the pressure of the receiver has no effect in increasing the rate of flow. Beyond this point occurs a loop of pressure, followed by other nodes and loops: three of each could be distinguished, strongly marked, when the pressure in the receiver (*i. e.* the atmosphere) was much below the limiting pressure; but as that value was approached, the nodes and loops became much reduced in magnitude, though more numerous, till, when the pressure in the neck was but little in excess of that in the atmosphere beyond, they disappeared altogether. The neck of limiting pressure formed in the case of the convergent orifice (cone of 13°—the most favourable form) coincided in position with the summit of the cone; at that point the stream of gas possesses a "wave-front" convex towards the orifice, and presenting a close analogy to the *vena contracta* of a liquid jet.

The author makes an ingenious, though somewhat vague comparison between the behaviour of a jet of gas and the rupture of a solid bar. The peculiarity of the jet lies in the fact that, when the pressure of the receiver is below the limiting value, the two portions before and behind the neck are absolutely independent of one another: the distribution of pressure in the expanding jet beyond the neck may vary in any manner without influencing the flow in the contracting portion in any way; so that the jet is, as it were, broken in two. There is, moreover, an analogy of mathematical conditions to be drawn between the solid and gas, since a solid bar may be broken by projecting a section of it with an impulsive velocity $>U_s\Delta$, where U_s is the velocity of sound in the material, and Δ the maximum strain it will stand, whilst the conditions at the neck of the jet can be expressed in a similar way.

It is incorrect to suppose that the contracted area mS of the jet represents any real section of it. On the contrary, the jet spreads out laterally immediately on escaping from the orifice, and the jet from apertures called "contracted" (such as openings in a thin plate) spreads out more than that from a convergent orifice. The apparent contraction of area is due to the divergent angles of the stream lines which meet at the orifice, and is only indefinitely represented by the section of maximum velocity previously referred to, and also by the subsequent maxima, which by a sort of rebound of the gradually expanding jet form a set of images of the first.

Experiments on the temperature of the jet before and after passing the orifice are also described; they were made on a steam-jet, to supplement the observations of Hirn, who measured the pressures only; and were found to give results in general accord with the author's theory.

Besides theoretical conclusions, the first of the two memoirs contains a collection of formulæ on the volume of outflow, and the time required to empty or fill a reservoir, which will be of practical service to engineers; and a description of an instrument, which, placed in the path of a steam-pipe, shows on a direct-reading scale the rate of flow of the steam at any moment. R. A. L.

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237. *Viscosity of Bromine.* **L. Kann.** (Berlin. Akad. Sitzber. 106. pp. 431–435, 1897.)—The coefficient of viscosity of bromine determined by the time of passage along a tube equals 0·014268 at 0° C.; 0·013584 at 5°; 0·012955 at 10°; 0·012363 at 15°; 0·011829 at 20°; 0·011327 at 25°; 0·010874 at 30°; 0·010469 at 35°; 0·010114 at 40°; 0·009793 at 45°; and 0·009489 at 50°. A. Gs.

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238. *Measurement of Small Displacements.* **A. Righi.** (N. Cimento, 6. pp. 349–352, 1897.)—The author describes a simple method of measuring small displacements, such as the motion of a point on an expanding bar. It consists essentially of a short lever supported at two close points on the same side of its centre of gravity by two very fine stretched fibres, one of which runs in an upward direction, and the other downward. The directions of the fibres will intersect on the vertical through the centre of gravity of the lever. The lower end of the lower fibre is fixed, and the upper end of the upper one is attached to the moving point. When the point moves upward or downward, the lever is tilted, and the angle of tilt is measured by a telescope, or lamp, and scale. In the actual instrument the suspension is bifilar; a thread of three cocoon-fibres is formed into a rectangle, the two upper corners of which are fastened to a rod connected with the moving point, and the two lower corners to a similar rod connected with the fixed point. The thread passes between two jaws at each end of a crosspiece attached horizontally at right angles to the lever. By this means errors due to torsion of the fibre are avoided; and by using short fibres changes in length due to humidity of the air do not cause any appreciable error. The author has succeeded in magnifying a small motion twenty thousand fold by this apparatus. J. L. H.

239. *Hydrometer.* **Vandevyver.** (Journ. Phys. Chem. Élem. 13. pp. 24–26, 1897.)—This is a hydrometer with a thin stem and long cylindrical bulb divided by a diaphragm into two parts, an upper and a lower. The upper contains air, and the lower, which is closed by a stopper, is filled with the liquid whose specific gravity has to be determined. The hydrometer is then floated in water, and the specific gravity read off on the stem which is previously calibrated. J. B. H.

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240. *Physical Pendulum.* **J. S. Stevens.** (Amer. Journ. Sci. 5. p. 14, 1898.)—In determining *g* by the common form of physical pendulum, error is introduced by the fact that the knife-edges and clamp affect the moment of inertia and centre of gravity of the pendulum. The author avoids this by boring a hole through a brass cylindrical rod about 8 cms. from one end. The knife-edges are screwed a little way into the hole, one on each side, and their mass adjusted so that they compensate for the mass of brass bored out. The centre of gravity of the system remains that of the original bar. The source of error would be entirely removed if the centre of oscillation of the triangular knife-edges were in the same horizontal plane as that of the removed cylinder. If the radius of this cylinder be r, the distance from the centre of oscillation to the point of suspension is, in the case of the triangle $\frac{5}{4}r$, and in the case of the cylinder $\frac{3}{2}r$. Allowing for the relative densities of steel and brass, the knife-edges may be so constructed and inserted that this result may be brought about. If, however, this error be neglected, the effect will be a raising of the centre of oscillation, in the region from which the brass has been removed, of $\frac{1}{4}r$. E. C. R.

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241. *Harmonic Analyser.* **A. A. Michelson** and **S. W. Stratton.** (Amer. Journ. Sci. 5. pp. 1–13, 1898.)—This is a machine for obtaining graphically the resultant of a number of simple harmonic motions, by means of the addition of forces of spiral springs. A lever in the form of a cylinder pivoted on its axis has attached to one side of it 80 small springs placed side by side; to the other side of the cylinder is a large spring parallel to the small ones, and of sufficient strength to counterpoise their force. The end of each small spring not attached to the cylinder is fixed to the end of a lever, to which a simple harmonic motion is given by means of an eccentric, the motion being conveyed to the lever by a rod which receives its motion from a rocking-lever worked by the eccentric; by sliding the rod along the rocking-lever, the amount of motion given to the end of the spring, or the amplitude of the term in the Fourier series represented by that spring, can be adjusted. The resultant motion of the cylinder is recorded by a pen, connected with a lever attached to the cylinder by a fine wire. Under the pen moves a slide with a speed proportional to the angular motion of a cone driving the eccentrics. To represent the succession of terms of a Fourier

series, the eccentrics have periods increasing in regular succession from 1 to 80. This is accomplished by gearing to each eccentric a wheel the number of whose teeth is in the proper ratio. These wheels are all fastened together in the same axis, and form the cone before referred to. The machine is capable not only of summing up any given trigonometrical series, but can also perform the inverse process of finding for any given function the coefficients of the corresponding Fourier series. The paper is illustrated with many specimens of curves obtained by use of the machine. E. C. R.

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242. *Deformation of Metals.* **M. Brillouin.** (Comptes Rendus, 126. pp. 328–330, 1898.)—This is a note on a theoretical investigation of the properties of commercial metals, which will appear shortly in the 'Journal de Physique.' The author considers the commercial metals as heterogeneous structures built up of elastic crystals to which the laws of elasticity apply, and between the crystals a viscous cement of metal which obeys the laws of viscosity. Considering the effect of stress on such a mass, he is able to explain all the phenomena connected with stresses in metals, such as time lag, hysteresis, permanent set, etc. J. B. H.

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243. *Apparent Exceptions to Hooke's Law.* **M. Brillouin.** (Annal. Chim. Phys. 13. pp. 231–260, 1898.)—This paper contains a discussion of cases in which there appears to be a departure from Hooke's Law, due, however, only to variability in the constraints of an elastic system. Certain general theorems are given, and particular cases discussed by Hertz (Crelle's Journ. 1882) are examined in further detail. When an elastic body is maintained in equilibrium by forces applied over a surface (*e.g.* a bar held by screw clamps), if a change of stress causes the area over which the forces are applied (*i.e.* area of contact of the clamps) to change, then the strain will not in general be proportional to the stress, even for infinitesimal strains, although Hooke's law remains true. The first case considered in detail is that of Auerbach's method of testing hardness (Wiedem. Ann. 43. p. 88), in which a spherical point is pressed on a flat plate till rupture occurs. The author considers that his theory accounts satisfactorily for the observed phenomena, and that the fracture depends not on the ordinary elastic properties of the substance, but on a superficial elasticity, which therefore is suitable for defining the "hardness" of the mineralogists. The knife-edges of pendulums used in geodetic survey are, according to the author, insufficiently strong for the weight they usually carry, so that they penetrate to some extent into the agate planes, and the pendulum acquires a rolling motion which introduces a quasi-viscous resistance and an inaccuracy in the determination of gravity; lighter pendulums should be used. A chain composed of equal links of circular section is a case easily worked out, in which the elongation is not proportional

to the load. Levelling screws with round points give way to an extent proportional to the $\frac{2}{3}$ power of the load on them. Care should be taken that the centre of gravity of an instrument remains rigorously fixed for all the movements that the instrument may have to make: thus a telescope may very well be shifted through half a second by the giving of the supports, in case the load is unequally placed. Supports resting on a hole-slot and plane necessarily give to an unequal extent. R. A. L.

LIGHT.

244. *Solar Light.* **A.** and **A. Garbasso.** (N. Cimento, 6. pp. 313-321, 1897.)—The researches of Langley with the bolometer have furnished curves showing the intensity of the light of each wave-length in the solar spectrum. From these curves the amplitude of each single vibration can be found, this being proportional to the square root of the corresponding intensity. The separate vibrations are all superposed on the medium transmitting the light, so that the resultant motion of the medium is the algebraic sum of the separate vibrations, the number of which is infinite. The authors have taken from Langley's curve the ordinates corresponding to wave-lengths at equal small distances apart, and by assuming all vibrations to be in the same phase have determined numerically the motion resulting from their superposition. It proves to be a highly damped periodic motion, the wave-length of which is about 0·00017 cm., and therefore large in comparison with the wave-length of the brightest portions of the spectrum (0·00006 cm.). The logarithmic decrement of the vibration appears to be about 3·3. J. L. H.

245. *Transformation of Röntgen Rays by Metals.* **G. Sagnac.** (Comptes Rendus, 125. pp. 942-944, 1897.)—There is no appreciable regular reflection from metals even from the surface of mercury at an angle of 75°. The secondary rays emitted by the metal under these circumstances pass some centimetres through the air. They are sharply bounded by the plane of the metallic surface, and therefore travel in straight lines without diffraction. The position of this sharp boundary is not affected by a prism of paraffin, and therefore there is no refraction; they are not regularly reflected by a metallic surface, but are diffused just like the original Röntgen rays. They traverse aluminium; they discharge electrified bodies, and this explains the action of metals in the discharge of conductors directly impinged upon by Röntgen radiations: coming from different metals they have different penetrative powers. They differ from Röntgen rays in being less fully transmitted through various substances, such as metals, glass, mica, paraffin, black paper, air; and even aluminium transmits them feebly, but it diffuses them and makes them undergo another transformation. These secondary radiations from metals seem to bear the same relation to the original Röntgen rays, as the rays emitted during luminescence do to the impinging rays. Aluminium does not produce these secondary rays. A. D.

246. *Discharge of Conductors under Röntgen Rays.* **G. Sagnac.** (Comptes Rendus, 126. pp. 36–40, 1898.)—The following phenomena are not explained by M. Perrin's views as to gas effect and metal effect. The surface of a metal, impinged upon by Röntgen rays, gives off new rays ("secondary radiations of the metal M") which are much more absorbed than Röntgen rays; they do not traverse the soft parts of the human hand, but they discharge conductors after the manner of Röntgen rays, apparently not by meeting them or the lines of force, but by making the air electrically conductive. The photographic effect of these secondary rays falls off rapidly with increase of distance; and black paper shields the plate somewhat when these rays come from copper, more when from zinc, and specially when from tin or lead. The secondary rays are absorbed by a thickness of the same metal as has given rise to them, about one-hundredth of the thickness which would be necessary in the case of Röntgen rays; and this explains M. Perrin's having found that the metal-effect per unit of surface is independent of the inclination. The effect of metal cannot be explained by superficial ionisation, because it is manifest at a distance; it rather appears that the air is rendered conductive both by the Röntgen rays and by the secondary metal-rays. A. D.

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247. *Photographic Negatives from Printing Blocks, etc.* **A. Guébhard.** (Comptes Rendus, 126. pp. 40–43, 1898.)—If a plate, very slightly fogged, be pressed against a printing-block well cleaned, with the developer filling the hollows of the block, and the whole left to itself, the developer will act along the hollows and not along the ridges, and make a negative from which a reversed positive can be made. If a coin be treated in the same way, the varying thicknesses of developing solution produce corresponding amounts of reduction, so that the negative gives the coin in relief, but with markings due to capillary forces. A. D.

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248. *Change of Phase through Metallic Reflection.* **H. Kath.** (Annal. Phys. Chem. 62. pp. 328–352, 1897.)—The experiments were made with absolutely pure metallic mirrors obtained by placing glass plates next kathodes of silver or gold in a vacuum-tube. An even deposit on the glass was produced by the disintegration of the kathode in an atmosphere of hydrogen. It was found that the change of phase is an acceleration in the case of silver and gold, amounting to $0{\cdot}55\,\lambda$ in the case of silver in air, and to about $0{\cdot}25\,\lambda$ in the case of gold in air. The acceleration is independent of the incidence in the case of silver, but in the case of gold it increases to $0{\cdot}5\,\lambda$ at grazing incidence. For platinum the acceleration is $0{\cdot}39\,\lambda$. E. E. F.

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249. *Measurement of Refractive Index.* **M. G. Weiss.** (Journal de Physique, 6. pp. 688–690, 1897.)—The author extends

the definition of the "power" of an optical system to the case where the initial and final media are different by calling n/f the power, where n is the index of the final medium, and f the focal length of the system; this has the same value whichever way the light traverses the system. To measure this power p, an object of length O is placed in the first focus, which gives an image at infinity; this image is viewed by an astronomical telescope, and an image of length I is formed in the focal plane of the object-glass. O and I are easily seen to be connected by the relation $p/p' = \mathrm{I}/\mathrm{O}$, where p' is the power of the object-glass. If O be kept the same, then a scale to measure I can be devised which shall give the power p required at one reading; but the most delicate method is to measure I by means of a cross wire in the focal plane moved by a micrometer-screw. When the initial and final media are different, these can be bounded by plane surfaces which do not alter the focal lengths or the power. The index of a lens can be found by plunging it into two media in turn and measuring the two powers; if n is the index required, n', n'' the indices of the two liquids, and p', p'' the powers found, then $n = n''p' - n'p''/p' - p''$; the most convenient media are air and distilled water. To measure the index of a liquid, a drop of it is placed between two plane convex lenses with their convex surfaces turned towards each other, and the power of the system is measured; we get

$$p = (n - n')\left(\frac{1}{\mathrm{R}} - \frac{1}{\mathrm{R}'}\right),$$

n being the index of the liquid, n' that of the glass; R, R′ the radii of the surfaces. Hence $n = n' - \mathrm{A}p$; the constant A can be found once for all by making an experiment with distilled water.
R. S. C.

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250. *Newton's Rings in Turbid Media.* **J. Stark.** (Annal. Phys. Chem. 62. pp. 368–373, 1897.)—The author deals with the rings seen in a plate of glass with a very slight layer of lampblack, obtained by slightly smoking the plate. The lampblack is in reality a layer of precipitated stearine containing finely divided particles of soot. Hence the layer forms a turbid medium. The rings observed are in reality diffusion-rings. They are well seen when the smoke is deposited on a metal plate. In all cases, the red is very feeble, and looks brownish. This is due to the fact that the medium diffuses the longer waves less than the shorter ones.
E. E. F.

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251. *Apparatus illustrating the Rainbow.* **S. Marcucci.** (N. Cimento, 6. pp. 325–331, 1897.)—The author has previously described an arrangement of jointed rods which serves to determine the direction of a ray of light refracted at a spherical surface. He now shows how it may be applied to illustrate the conditions of minimum deviation when a ray passes into a refracting sphere, suffers one or two internal reflexions, and emerges again. J. L. H.

252. *Simple Demonstration of the Zeeman Effect.* **W. König.** (Annal. Phys. Chem. 63. pp. 268-272, 1897.)—Two sodium flames are observed in the same line of vision, the farther one being placed in a magnetic field which can be established at will. The flames are viewed at right angles to the lines of force through a dichroiscope or a simple doubly-refracting prism, which gives two images of them. The emission flame being colourless to begin with, only one of the two images brightens up on making the field, that being the one whose vibrations take place in a vertical direction. If the emission-flame is in addition coloured by another salt, a very perceptible dichroism of the two images is obtained.

E. E. F

HEAT.

253. *The Law of Mixture of Gases.* **P. Sacerdote.** (Comptes Rendus, 126. pp. 338–340, 1898.)—When Berthollet's experiment, in which equal volumes of two different gases at the same temperature and pressure are allowed to diffuse into each other without change of the temperature and total volume, is repeated with all available accuracy, the pressure is found to increase, but only slightly. Thus with N_2O and CO_2 under 75·940 cm. of mercury a rise of ·008 cm. was observed, which may be ascribed to errors of experiment; and with SO_2 and CO_2 under 76·569 cm. the rise is 1·36 cm. But the rise, as calculated from the assumption of Dalton's law of partial pressures, together with the experimentally determined deviations of the gases from Boyle's law, is considerably greater. Hence Dalton's law of partial pressures is less exact than the alternative form of it, viz.: *the volume occupied by a mixture of gases is equal to the sum of the volumes of the separate gases when at the pressure and temperature of the mixture.* R. E. B.

254. *The Mixture of Gases.* **A. Leduc.** (Comptes Rendus, 126. pp. 218–220, 1898.)—Experiments on atmospheric air and with mixtures of N_2O and CO_2 and of CO_2 and SO_2 show, as in the last Abstract, that Dalton's law of partial pressures for mixed gases is not so exact as his law of partial volumes, which Leduc expresses thus:—*in a mixture each gas should be considered as under the pressure of the whole.* He further concludes that when nitrogen and argon are mixed there is a rise of pressure, so that in 10,000 volumes of atmospheric nitrogen there are 9880 volumes of nitrogen and 119 volumes of argon. R. E. B.

255. *The Cooling of a Heterogeneous Bar.* **W. Stekloff.** (Comptes Rendus, 126. pp. 215–218, 1898.)—This is a mathematical discussion of the integration of the equation

$$\partial^2 V/\partial x^2 + \{kp(x) - q(x)\}V = 0$$

for the values given by $b > x > a > 0$, when the condition $\partial V/\partial x = hV$ holds for $x = a$, and the condition $\partial V/\partial x = HV$ for $x = b$; p and q being positive functions, and k, h, H positive constants. It depends on a method given by Poincaré. R. E. B.

256. *Meaning of* PV/T *in Theory of Gases.* **E. Boggio-Lera.** (N. Cimento, 6. pp. 331–333, 1897.)—The author replies to the criticism of Signor Del Lungo (see Abstract No. 35, Jan. 1898), pointing out that he did not assert the equality of the numerical values of PV/T and the mechanical equivalent of heat. He called attention to the fact that if PV be taken as a measure of the dynamical energy of the gas, and T as proportional to its thermal

energy, the ratio of these two quantities is the mechanical equivalent of heat. In other words, the dimensions of PV/T are the same as those of the mechanical equivalent of heat. J. L. H.

257. *Comparison of Thermometers.* **E. Gumlich** and **K. Scheel.** (Zeitschr. Instrumentenk. 17. pp. 353–356, 1897.)—This is a communication from the Reichsanstalt on a comparison of thermometers of the same glass but of two different types—the one, the rod type, having the scale engraved on the stem; and the other, the enclosed scale type, having the scale on a strip of white glass fastened behind the capillary stem, both stem and scale being enclosed in an outer glass tube attached to the bulb. A number of thermometers were compared, and the results of the comparisons are given in tabular form in the paper. The general conclusion arrived at is that for an accuracy of over 0°·01 only those thermometers of the enclosed scale type should be used which have been compared directly with one of the rod type, or for which the expansion of the scale is known and can be allowed for. J. B. H.

258. *Ternary Mixtures,* III. **W. D. Bancroft.** (Journ. Phys. Chem. 1. pp. 760–765, 1897.)—If two liquids A and C are partially miscible at a certain temperature t and a third liquid B is miscible with both in all proportions, there exists a series of solutions at this temperature such that clouding (*i. e.* precipitation) will occur on the addition of a drop of either A or B. These may be represented on a triangular diagram by a curve which is the boundary between the regions corresponding to saturated and unsaturated solutions. This curve may be divided into four stretches—xy, yz, zy', $y'x'$, where x, x' are its intersections with the AC line on the A and C sides respectively, and y, y' are the points where it is touched by tangents drawn respectively from the A and C corners; along xy addition of C produces cloudiness but not addition of A; along $x'y'$ addition of A produces cloudiness but not addition of C; along yzy' addition of either A or C will produce cloudiness, but for the part yz the resulting solution will contain more of A than the original solution, while for the part zy' there will be more of C. The general form of this boundary line is found to be

$$(a-s_2c)_n(c-s_1a)/b^{n+1}=k,$$

where a, b, c are the volumes of the liquids A, B, C in a given volume of the solution, s_1 the solubility of C in A and s_2 the solubility of A in C, and n, k are constants which differ for the four stretches. There is not necessarily discontinuity at these points y, z, y', but only one case has as yet been found in which discontinuity is absent. R. E. B.

259. *Temperature of Wires traversed by a Current.* **M. Sala.** (N. Cimento, 6. pp. 333–336, 1897.)—When a wire of resistance R ohms and surface S sq. cms. is traversed by a steady current of C amperes, the excess of its temperature (θ) above the surrounding medium is given by the equation $0{\cdot}24\ C^2R = KS\theta$, assuming Newton's law of cooling; K is the emissivity of the surface of the wire. The author describes experiments in which the temperature of the wire was measured by its extension, the wire being vertical and of 23 metres length. The results show that K increases with decrease of diameter of the wire, but remains constant for the same wire within somewhat wide limits of temperature. Newton's law of cooling is therefore obeyed, but conduction apparently modifies the values of K. The amount of heat lost varies with the physical and chemical nature of the surface, although the loss is chiefly due to convection by air, the radiation being small. J. L. H.

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260. *Thermodynamic Potential.* **J. D. van der Waals.** (Archives Néerlandaises, 30. p. 137; Journ. de Physique, 6. p. 600, 1897.)—When two phases of a substance coexist in equilibrium, the pressure, temperature, and thermodynamic potential are respectively the same in the two phases at any point of contact. A kinetic explanation of these conditions as regards pressure and temperature has already been given. It is here now shown that the condition of the equality of the thermodynamic potential is the expression of the kinetic condition of the equality of interchange of molecules from each phase to the other. The author applies his method to the consideration of (i) a single substance; (ii) a mixture of two substances. R. E. B.

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261. *The Plait-curve for a Mixture of two Substances.* **J. D. van der Waals.** (Archives Néerlandaises, 30. p. 266.) *The Critical Conditions of a Mixture.* **J. D. van der Waals.** (Archives Néerlandaises, 30. p. 278; Journ. de Physique, 6. p. 601, 1897.)—The plait-curve, or the locus of the points indicating the state of a mixture of two substances when the temperature and pressure are such that the composition and density of the two coexisting phases are the same, is represented by a differential equation from which its singularities and trend can be inferred in cases where certain observations cannot be made. The author finds that there are two remarkable points, of which one is a point of tangency of the plait-curve with the curve of maxima and minima pressures; and his theory is in sensible agreement with Kuenen's experiments on mixtures of N_2O and ethane. He further formulates the conditions of relative steepness of the plait-curve and that of vapour-pressure which the mixture would have if it were not separable into its two elements. R. E. B.

262. *Theory of Fusion.* **M. Brillouin.** (Annal. Chim. Phys. 13. pp. 264–275, 1898.)—The author insists that the essential feature of fusion is the loss of rigidity, and that too much attention has been paid in considering the subject thermodynamically to the latent heat, which is rather accidental; he considers that "pasty fusion" is change of state unaccompanied by absorption of heat, so that temperature equalisation does not take place of its own accord. He develops a notion of the rigidity becoming *negative* in liquids, and draws an imaginary curve $\mu=0$ as boundary between possible liquid and solid states, but without sufficiently explaining how the solid properties are to be measured by a single coefficient; and endeavours to indicate the course of isobaric lines on a (v, T) diagram, grouped round a sort of critical point, and by their means to account for the various phenomena of sharp and gradual fusion, undercooling of liquid, etc. The discussion is highly ingenious and suggestive, but is very far in advance of our experimental knowledge. R. A. L.

263. *Theory of Liquids with Unassociated Molecules.* **G. Bakker.** (Journ. de Physique, 6. pp. 577–588, 1897.)—This article contains an account of the author's theory of liquids, and gives nearly the same theorems as have already been published in German (see Phys. Soc. Abstracts, No. 53, Jan. 1895; No. 248, May 1897; and No. 390, July 1897), and numerical data in support of the deduction that the true latent heat of vaporisation is (for the same liquid) proportional to the difference of densities of liquid and vapour. R. A. L.

ELECTRICITY.

264. *Distribution of Electricity and C. Neumann's Problem.* **W. Stekloff.** (Comptes Rendus, 124. pp. 1026–1029, 1897.)—Let S be a closed surface, M, M′ two points on it, MM′$=r$. Let the angles between MM′ and the normals drawn outwards at M and M′ be ϕ, ϕ'; let ds be an element of S—$d\nu$, $d\nu'$. Let ρ_0 be any arbitrary function of position on S. Let

$$\frac{dV_0}{d\nu} = \rho_0.$$

Form the series of integrals

$$V_1 = \iint \rho_0 \frac{1}{r}\, dS, \qquad \frac{dV_1}{d\nu} = \rho_1,$$

$$V_2 = \iint \rho_1 \frac{1}{r}\, dS, \text{ etc.}$$

Then it can be shown that the greatest and least values of V_2, as it varies from point on S, lie between the greatest and least values of V_1, and so on. So that, continuing the process indefinitely, we come in the limit to $V_\kappa =$ constant. $V_{\kappa-1}$ is the density of the equipotential distribution. By a further application of the same method is obtained the series,

$$V = \frac{1}{2\pi}\int(\lambda\rho_0+\lambda^2\rho_1+\ldots+\lambda^{\kappa+1}\rho_\kappa+\text{etc.})\frac{1}{r}\, dS;$$

where λ is positive and less than unity. With $\lambda=1$, we have the solution of Neumann's problem for the interior space; with $\lambda=-1$, for the exterior space. S. H. B.

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265. *Potential of Opposite Charges on a Surface.* **A. Liapounoff.** (Comptes Rendus, 125. pp. 694–696, 1897.)—If μ be the distance between the two charged surfaces at the point P, the potential at Q, any external point, of an element ds of the double surface is

$$W = \frac{\mu \cos \phi ds}{r^2}.$$

And for the whole surface

$$W = \int \frac{\mu \cos \phi ds}{r^2}.$$

This is called the "potentiel d'une double couche."

Let dn be an element of the normal to the surface. Then our author says it will be admitted generally that if P and P′ be two points on the surface which are made to approach one another meeting in the point M_0,

$$\lim\left(\frac{dW}{dn}\right)_P = \lim\left(\frac{dW}{dn}\right)_{P'}$$

but this proposition has never yet received strict proof.

First establish the two theorems.—I. Let μ be any continuous function. Suppose that at the point M_0 on the surface the normal sections are all of finite and determinate curvature. Then, if the points P P′ on the surface be made to approach M_0, always maintaining the relation $PM_0 = P'M_0$, we shall have

$$\lim\left(\frac{dW}{dn}\right)_P - \lim\left(\frac{dW}{dn}\right)_{P'} = 0.$$

Theorem II. The preceding conditions for the point M_0 being satisfied, take M_0 for origin and ρ, θ for polar coordinates in the tangent plane at M_0, and assume

$$\frac{1}{2\pi}\int_0^{2\pi} \mu d\theta = \bar{\mu}.$$

Then if α be any positive number such that

$$\lim_{\rho=0}\left(\frac{\bar{\mu}-\mu_0}{\rho^{1+\alpha}}\right) = 0,$$

μ_0 being the value of μ at M_0, we shall have determinate limits for

$$\left(\frac{dW}{dn}\right)_P \quad \text{and} \quad \left(\frac{dW}{dn}\right)_{P'},$$

and these limits are equal. The complete analysis is promised in a future communication. S. H. B.

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266. *Capacity of an Anchor-ring Condenser.* **N. Boulgakoff.** (Écl. Électr. 14. pp. 67–69, 1897.)—Having in his former papers (see Phys. Soc. Abstracts, No. 620, Oct. 1897, and No. 707, Dec. 1897) obtained the capacity of a conductor in the form of a ring, M. Boulgakoff now proceeds to the problem of the capacity of a condenser of the same form. The equation to the two surfaces forming the ring shall be $\lambda=c_1$, $\lambda=c_2$, λ being the peripolar coordinate defined in the former papers.

The potential at any point between the surfaces is

$$R\Sigma\left(M_n J_n^0(\lambda)+N_n A_n^0(\lambda)\right)\cos n\omega \quad . \quad . \quad . \quad . \quad (3)$$

in the notation of the former papers, that is

$$R = \sqrt{1-2\lambda\cos\omega+\lambda^2},$$

$$J_n^0(\lambda) = \frac{1}{2\pi}\int^{2\pi}\frac{\cos n\omega\, d\omega}{\sqrt{1-2\lambda\cos\omega+\lambda^2}},$$

$$A_n^0(\lambda) = \frac{\lambda^n}{2\pi}\int_0^{2\pi} \frac{d\partial}{\left(\lambda^2 \cos^2 \frac{\partial}{2} + \sin^2 \frac{\partial}{2}\right)^{\frac{2n+1}{2}}}.$$

V_1 is the potential of the interior ring-surface, V_2 that of the exterior. Since for $\lambda = c_1$ the expression (3) is V_1, and for $\lambda = c_2$, V_2,

$$M_n J_n^0(c_1) + N_n A_n^0(c_1) = 2V_1 J_n^0(c_1)$$

$$M_n J_n^0(c_2) + N_n A_n^0(c_2) = 2V_2 J_n^0(c_2), \text{ where } n > 0,$$

$$M_0 J_0^0(c_1) + N_0 A_0^0(c_1) = V_1 J_0^0(c_1)$$

$$M_0 J_0^0(c_2) + N_0 A_0^0(c_2) = V_2 J_0^0(c_2);$$

whence in the notation of the former papers,

$$N_n\left(\frac{1}{k_n c_1} - \frac{1}{k_n c_2}\right) = V_1 - V_2.$$

Then by the usual relation

$$-\,4\pi e_1 = \frac{dV}{d\nu} + \frac{dV'}{d\nu}$$

he obtains

$$-\,4\pi e_1 = -\,\frac{R_1^{\,3}}{2a}\,\frac{2\Sigma_{n=0}^{n=\infty}\frac{Nn}{J_n^0(c_1)}\cos n\omega,}{\pi c_1(1-c_1^{\,2})}$$

R_1 being $\sqrt{1-2c_1 \cos\omega + c_1^{\,2}}$.

An element of surface is, as before shown,

$$dS = \frac{2a^2 c_1(1-c_1^{\,2})\,d\omega\, d\phi}{(1-2c_1 \cos\omega + c_1^{\,2})^2}.$$

If $E = \int e\,dS$,

$$E = \frac{a}{2\pi^2}\int_0^{2\pi} d\phi \int_0^{2\pi} \frac{N_n}{J_n^0(c_1)} \cos n\omega \frac{1}{R}\, d\omega;$$

also

$$E = 2a\Sigma N_n = 2a\Sigma \frac{V_1 - V_2}{\frac{1}{k_n(c_1)} - \frac{1}{k_n(c_2)}}.$$

The capacity required is

$$\frac{E}{V_1 - V_2}\Sigma_{n=0}^{n=\infty} \frac{1}{\frac{1}{k_n(c_1)} - \frac{1}{k_n(c_2)}}.$$

S. H. B.

267. *Motion of a Charged Body.* **O. Heaviside.** (Electn. 40. pp. 379–380, 1898.)—This is a criticism of the statement, made at different times by several physicists, that a charged body cannot move at a greater speed than that of light, because at this speed the energy of the charge is infinite, and an infinite amount of work must therefore be done on the charged body: it must experience an infinite resistance. The author points out that the fallacy arises from the assumption that a disturbance of electric displacement travels with infinite speed. If it be assumed to travel with the speed of light, a charged body moving with this speed will not disturb the ether in front of itself, but will experience a pull-back requiring expenditure of energy to keep up its speed. Again, if a positive charge and an equal negative one be moved together with the speed of light, the energy required is finite whatever be the velocity of propagation of polarisation in the ether; so that, according to the usual assumption of infinite velocity, two opposite charges might move together at the speed of light, but they could not be moved separately at this speed.

J. L. H.

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268. *Resistance and Self-Induction.* **J. Schurr.** (Journ. de Physique, 6. pp. 588–592, 1897.)—Certain theorems are given on the geometrical relations between the resistance and self-induction of a pair of conductors immersed in an infinite medium, showing how a knowledge of the one will enable the other to be calculated, in terms of the assumed permeability and conductivity of the medium. The article hardly admits of an abstract. R. A. L.

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269. *Electrification of Air.* **E. Warburg.** (Annal. Phys. Chem. 63. pp. 411–418, 1897.)—A needle was mounted in a tube as an electrode, and was surrounded by a net of wire gauze serving for another electrode. The tube was provided with a cross tube through which a current of air was blown, which traversed two holes in the wire gauze and eventually entered a brass tube with a cotton-wool plug enclosed in a wire net, the brass tube being connected with an electrometer which indicated any electrification of the emerging air-current. Such electrification is indicated at first, but as the dust is eliminated it gradually falls to nearly zero. When the air is dry, some needle-points apparently electrify it. But since such electrification is stopped on closing the holes in the wire net, it is evident that the charge must be conveyed by particles large enough to be stopped by the meshes. Experiments showed that ultra-violet light had no effect on the discharge. If the air is blown past a platinum wire rendered incandescent by a current, a charge is observed which is due to the disintegration of the wire. In hydrogen no disintegration takes place, and no electrification is observed.

When a current of moist air is sent through the apparatus, an apparent electrification is obtained. But this disappears on warming the air-current, so that it is probably due to condensed water particles. All the results therefore speak against the direct electrification of a gas. E. E. F.

270. *Magnetic Survey of Sicily.* **L. Palazzo.** (Roma, R. Accad. Lincei, Atti 6. 2. pp. 331–337, 1897.)—This paper contains a short abstract of the results the author has obtained when carrying out a magnetic survey in the island of Sicily, the complete paper being published in vol. 18 of the 'Annali dell' Ufficio centrale Meteorologico e Geodinamico.' Marked disturbances were noticed due to the volcanic rocks. From the results of his measurements and of those made in 1882 by Chistoni, the author finds the following values for the secular change for the epoch 1881–1891:—

Declination	−5′·6 per annum.
Dip	−1′·4 „
Horizontal force	+0·000017 „

W. W.

271. *Electric Point Discharges.* **S. Arrhenius.** (Annal. Phys. Chem. 63. pp. 305–313, 1897.)—The strength of an electric point discharge is measured by a torsion due to the reaction of the point. A wire cross bears four needle-points at its ends, turned at right angles to the arms, all in one direction. The cross is suspended by the centre by means of a metallic wire inside a vessel in which the pressure of the gas can be regulated. An electrometer and a galvanometer are inserted in the circuit, and also an influence-machine which supplies the current. The amount of the torsion is measured by a mirror attached to the cross. On inserting a large condenser in the circuit, the deflection becomes very constant. It is found to increase a little more slowly than the quantity of electricity issuing from the points. In all cases, the quantity of electricity leaving the points is less in the case of negative than in the case of positive electricity. This is the more clearly shown the lower the pressure. It is possible that the reverse is the case at a pressure of several atmospheres. In the more permanent gases, the reaction of the wheel is proportional to the pressure of the gas. In others, like acetone or ethyl ether, it increases more rapidly. This rule, however, only applies to positive electricity. For negative electricity, the reaction always increases more rapidly than the pressure. E. E. F.

272. *Electric and Magnetic Wind.* **O. Lehmann.** (Annal. Phys. Chem. 63. pp. 285–304, 1897.)—The phenomenon of electric wind is capable of explaining certain properties of stratified discharges and of the arc. When discharge takes place between two plates provided with points, air-currents are set up symmetrically from both sides. They may be made visible by means of tobacco smoke, or by introducing a heavier gas which produces

refraction. The whirls produced may be explained by supposing that particles are projected from each point towards the opposite point and plate. As regards the explanation of this projection, the electrification theory is untenable, and the dissociation theory meets with a difficulty in the case of monatomic gases. If a layer of gas intervenes between the two plates which from any cause has a different dielectric constant, partial discharge takes place within it, and stratification is produced. Electric wind is the cause of the unsymmetrical shape of the arc, which is blown away from the negative pole. If the electric wind occurs in a strong magnetic field the stream lines of the ions, and hence also of the air, must be charged in obedience to the electromagnetic forces, and the new stream may be designated by the term "magnetic wind." An arc playing between the inner edge of a carbon-circle and a rod in its centre rotates rapidly when placed in a magnetic field with its lines of force normal to the plate. In a large highly-exhausted "electric egg" a comet-like phenomenon sometimes projects towards one side, which rotates round the line joining the electrodes when a magnet is approached to it from the outside. This is also probably a phenomenon of magnetic wind. E. E. F.

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273. *Influence of Magnetism on Vacuum Discharges.* **A. Paalzow** and **F. Neesen.** (Annal. Phys. Chem. 63. pp. 209–220, 1897.)—To ensure the symmetrical influence of the magnetic field upon the vacuum-tube, the authors used either a strong magnetising coil or perforated pole-pieces, instead of laying the tube across the poles. When a vacuum-tube is introduced into the perforations of the two pole-pieces, the portions of the tube lying inside the iron suffers no influence, but the portion between the two pole-pieces is subjected to a field symmetrical from every side. In the case of the magnetising coil the influence increases towards the axis, whereas in the case of the hollow pole-pieces it increases towards the walls of the tube. To examine simultaneously the effect of the field in an axial and equatorial direction, a compound vacuum-tube was made in the form of a cross, so that the direction of the discharge could be made parallel or perpendicular to the lines of force at will.

In the axial position, the magnetic field acts as if it increased the pressure of the air which is being pumped out. It therefore retards the setting-in of the discharge, and prolongs it after the minimum pressure has been passed. The action is reversed, however, when the kathode itself is brought under the influence of the field, instead of the space between the two electrodes.

In the equatorial position, the magnetic field always reduces the intensity of the discharge, or even extinguishes it. These influences are accompanied by modifications in the light phenomena of the discharge. In the axial position, when the kathode itself is exposed to the field, the outermost kathode layer is quite blown away, and the other layers are compressed about the kathode. In the equatorial position, the negative light is extinguished and the positive light is pressed against the wall. The path of the current is thereby lengthened, and the current is eventually broken. A decided difference between paramagnetic oxygen and diamagnetic hydrogen was not shown. There is a certain amount of magnetic time effect, which the authors explain by a charge imparted to the individual molecules before the discharge sets in. E. E. F.

274. *Positive Light and the Dark Kathode Space.* **E. Wiedemann.** (Annal. Phys. Chem. 63. pp. 242–245, 1897.)—In high vacua, the resistance of the gas increases as the distance between anode and kathode is diminished. The author tested whether this is due to an influence of the dark space upon the anode itself or upon the positive light. He prolonged the anode by means of an inner tube penetrating into the dark space, and observed that the positive stratifications on issuing from the tube bent round backwards until they amalgamated with the negative glow-light. The current passes through the positive strata into the negative glow-light and thence through the dark space. Any disturbance of this sequence is compensated by a deformation of the light-effects.
E. E. F.

275. *Kathode Rays.* **M. Lamotte.** (Écl. Électr. 13. pp. 444–455, 1897.)—Contains an account of recent work, chiefly by E. Wiedemann, Ebert, and Schmidt, on the nature and properties of kathode rays, and the classification of the spectra of vapours when rendered luminous by the electric discharge. J. L. H.

276. *Phosphorescence and Kathode Rays.* **A. Sandrucci.** (N. Cimento, 6. pp. 322–325, 1897.)—When the discharge of electricity through a glass tube showing kathode rays is stopped, the glass exhibits phosphorescence. This may be either true phosphorescence, fluorescence due to continued emission of kathode-rays, or both combined. The author has examined these hypotheses, using various tubes inserted between the poles of a large horseshoe electromagnet; the magnet was sometimes excited during the passage of the electricity, and in other experiments only after the current of the induction-coil had been stopped. The results indicate that the kathode continues to emit kathode rays, which can be deflected by a magnet, for an appreciable time after the electric discharge in the tube has ceased. The residual fluorescence of the glass shows patches of greater intensity when the magnet is excited, which shift in position on breaking the current of the electromagnet. Further, the luminosity of the glass is a true phosphorescence.

The author points out that this behaviour of kathode rays does not admit of any simple explanation on the hypothesis that the rays are streams of negatively charged molecules, whereas it might be due to a vibration in the ether set up by the kathode, analogous to the vibrations of a tuning-fork after the operation of bowing it has ceased. J. L. H.

277. *Electrostatic Properties of Kathode Rays.* **W. Wien.** (Berlin Phys. Gesell. Verh. 16. pp. 165–172, 1897.)—The English physicists regard kathode rays as streams of negatively-charged particles: the German as processes in the ether. Wiechert has supposed them to consist of particles probably smaller than ordinary molecules: so has J. J. Thomson. If the kathode rays after passing through an aluminium window put to earth still bore negative charges, the hypothesis of charged particles would be the correct one; and the author shows that they do so. The rays bent by a magnet carry negative charges; those not deflected carry positive, but these do not get through aluminium. This points towards the latter consisting of larger particles than the former. The author has found magnetic deflection of the rays traversing a Lenard window, to an extent corresponding to a velocity equal to about one-third the velocity of light. A. D.

278. *Crookes Tubes.* **V. Machado.** (Comptes Rendus, 125. p. 945, 1897.)—In a Crookes tube containing the Maltese cross soldered to the anode there is, besides the shadow of the cross, a circular shadow on the antikathodic wall. This shadow is smaller than the cross. When a magnet is brought near, both shadows travel from the mid point; but the circular shadow travels much more than the cruciform one, and places itself at right angles to the magnetic field. The former seems to be the base of a conical region at right angles to the kathode disc; and this conical region seems to be devoid of any useful radiations. The active kathode rays then come only from the edges of the kathode disc; and the green fluorescence is in a ring outside this circular shadow. A. D.

279. *Electric Waves and Dust Figures.* **W. von Bezold.** (Annal. Phys. Chem. 63. pp. 124–131, 1897.) — The author describes the apparatus used in 1870 for the dust-figure experiments quoted by Hertz as to some extent anticipating his own work on electric waves. E. E. F.

280. *Hertzian Waves.* **E. Ducretet.** (Paris. Soc. Franç. Phys., Bull. 104. pp. 3–4, 1897.)—M. Ducretet showed the Society a very convenient form of oscillator and coherer. He described the apparatus used by Popoff at St. Petersburg in 1895: a coherer is placed in circuit with a relay which is set in action when the waves render the coherer conductive. The relay works a bell-hammer which also strikes the coherer, and a recording-point. M. Ducretet has modified this apparatus so as to make a working telegraphic recorder. A. D.

281. *Interferometer for Electric Waves.* **G. F. Hull.** (Phys. Rev. 5. pp. 231–246, 1897.)—The principle of Michelson's interferometer is applied to electric waves. The radiation from two spheres, sparking to each other in oil, is concentrated by a suitable parabolic mirror on a sheet of cardboard carrying parallel strips of tinfoil; by this means the radiation is half transmitted and half reflected. The two beams are made to return on their paths by reflection from plane mirrors, which can be moved in the direction of the beam; ultimately they fall on a receiver and produce interference. The receiver used, a coherer, consisted of small nails or pieces of wire about 1 cm. long, contained in a glass tube filled with oil, and was connected up to a cell and galvanometer.

The curve of interference was constructed by observing the change of resistance of the coherer brought about by the joint action of the two waves, as one mirror was altered in position. From the maxima and minima on this curve the wave-length was determined; and the effect of damping of the vibrations, both in the vibrator and the receiver, was clearly shown in the curves. The author concludes that the logarithmic decrement of the amplitude of oscillation is of the same order for the receiver as for the vibrator. From a number of interference-curves the period of the principal component in the radiation from the vibrator may be determined; and when the instrument is used as a refractometer the error in the index of refraction need not exceed one per cent.

J. L. H.

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282. *Behaviour of Selenite in an Electric Field.* **A. Righi.** (N. Cimento, 6. pp. 345–349, 1897.)—The equality of dielectric constant and square of refractive index, for dielectrics crystallising in the second, third, or fourth systems of crystals, requires that the axes of optic elasticity and those of electric polarisation must be coincident. The author has already determined the axes corresponding to the three principal indices of refraction for electromagnetic waves in selenite (see Phys. Soc. Abstracts, No. 416, July 1897, and No. 538, Sept. 1897). In the present paper he describes experiments to determine whether, in the case of selenite, the axis of maximum dielectric constant coincides with that of maximum refractive index—namely, the direction of the secondary non-fibrous cleavage. Circular discs of selenite were suspended horizontally by quartz fibres in an alternating electric field set up between two parallel plates. The plates formed the ends of a system of Lecher wires in which electric oscillations were excited, the wires being connected by metal bridges at suitable points. The frequency of the waves was about 20 million per second. It was found that the disc always tended to set itself with the direction of non-fibrous cleavage along the lines of force, and was only prevented from doing so by the torsion of the fibre. When the disc was placed with the axis of non-fibrous cleavage

parallel to the axis of the plates, it did not move on setting-up the electric field. The author therefore concludes that Maxwell's relation is true in the case of selenite. J. L. H.

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283. *Clark Cells.* **A. Dearlove.** (Electn. 40. pp. 386–387, 1898.)—The author defends the Clark cell as a reliable and durable standard, but prefers Clark's original process for setting it up to that which is specified by the Board of Trade. He gives the results of tests made on 21 cells recently set up from the same stock materials, the process being slightly varied. The results of the first 16 cells show a maximum variation between themselves of 4 parts in 10,000, and compare well with the value of the standard; the results of the last five, prepared according to the Board of Trade specification, are much less satisfactory. The platinum spirals are most easily amalgamated by placing them in boiling mercury. A. H. A.

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284. *Precipitation Primary Batteries.* **R. Lorenz.** (Zeitschr. Elektrochem. 4. pp. 305–309, 1898.)—In the majority of galvanic cells the electrolyte undergoes change, and has to be renewed from time to time; but by an adaptation of the author's method of preparing metallic hydroxides, cells can be constructed in which the chemical changes are virtually confined to the electrodes. The metal—zinc, for example—is placed in a solution of an alkali chloride, such as common salt, the other electrode consisting of platinum, copper oxide, or other suitable material; and on completing the circuit the metallic ions liberated at the kathode combine with the hydroxyl ions from the anode, and the metallic hydroxide is precipitated, the sodium chloride remaining unchanged. Numerous data are given concerning a zinc|common-salt|copper-oxide element constructed on this plan. The electrodes are plates 67 × 99 mm., about 30 mm. apart, and the salt solution contains 58·4 grams per litre. With an external resistance of 170 ohms the E.M.F. falls in the course of sixty-five hours from 0·99 to 0·70 volt, remaining stationary at about 0·9 volt for two or three hours after the initial drop. With 10 ohms the E.M.F. falls quickly to about 0·5 volt, and there remains constant for several hours, and the total quantity of electricity generated during this time amounts to about 65 ampere-minutes. The gelatinous precipitate of zinc hydroxide which gradually accumulates hinders free circulation; but with low external resistances the E.M.F. at once regains its original value on stirring. With 1 ohm, for example, the original E.M.F. of 0·27 volt, which in the course of 5 hours drops to 0·14 volt, thus immediately recovers; the total quantity of electricity amounts, as before, to about 68 ampere-minutes. The E.M.F. throughout is from 0·25 to 0·5 volt lower than with Umbreit's

"cupron"-element (zinc | caustic-soda | copper-oxide). Direct potential measurements with the aid of an auxiliary mercury | mercurous-chloride | potassium-chloride cell show that the falling-off of the E.M.F. takes place principally at the anode; and this is also the case with the "cupron"-element. These precipitation-cells work well at current-densities up to 0·005 ampere/cm.^{2}, and the exciting fluid is cheap and inoffensive; but against these advantages must be placed the low E.M.F. and the trouble of frequently removing the precipitated hydroxide. They mark a further step, however, towards the solution of the problem of converting the energy of coal directly into electrical energy, since the metal can be reproduced from the hydroxide in one operation by heating the coal. Similar cells can be formed with cadmium (0·632 volt), iron (0·297 volt), and magnesium (1·528 volt); in each case the gelatinous hydroxide of the metal being precipitated and the sodium-chloride solution remaining unchanged. J. W.

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285. *Shunt-Box Compensation.* **W. M. Stine.** (Amer. Journ. Sci. 5. pp. 124–125, 1898.)—The compensating resistances for keeping the resistance of a shunted galvanometer constant are ordinarily inserted between the galvanometer and the shunt. The shunting and compensating resistances are then fractions of the galvanometer-resistance which cannot be expressed simply, and are consequently difficult of adjustment. The author describes a shunt-box in which the compensating resistances are in the galvanometer-circuit outside the shunt. They are inserted together with the shunts by three-part plug sockets; one part is connected to the galvanometer, a second to the shunt, and the third to the outside circuit through the compensating resistance. The shunting resistances are then the ordinary simple fractions of the galvanometer-resistance, and the compensating resistances the fractions 0·999, 0·99, and 0·9, etc. If, therefore, three resistances of the fractional values 0·009, 0·09, and 0·9 are joined in series, the compensations are made by including one, two, or all three in circuit. G. H. Ba.

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286. *Measurement of Self-Induction by Alternating Currents.* **K. E. Guthe.** (Amer. Journ. Sci. 5. pp. 141–143, 1898.)—The author discusses some points in Rowland's paper on measurement by alternate currents (Abstract No. 144, Feb. 1898), and describes a method of measuring self-induction based on the same principle as Rowland's methods, which is especially adapted to measuring self-inductions comparable with, or smaller than, those of the dynamometer coils. Two separate currents from a two-phase generator, differing 90° in phase, are sent through the two dynamometer coils, and the dynamometer balanced to zero by adjustment of the resistances in circuit. The arrangement is calibrated by measuring the extra resistance required to again obtain balance when a standard self-induction is put in one of the circuits. If a

second balance be made with the unknown self-induction in circuit, the two self-inductions are proportional to their balancing resistances. G. H. BA.

287. *Self-Induction Measurements.* **Thiermann.** (Elect. Runds. 15. pp. 32–33, 1897.)—A description is given of a method devised by Thiermann for the measurement of coefficients of self-inductions. The self-inductive conductor under test is connected, in parallel or otherwise, by means of a special key, to a non-inductive conductor of equal resistance. One pair of extremities of the two conductors is permanently joined; the other pair may be joined or disconnected by the key. This second pair of extremities is also connected to a ballistic galvanometer. When the key is closed the galvanometer is short-circuited, and the two conductors are thus connected in parallel. When the key is open, the two conductors and the ballistic galvanometer are in simple circuit with one another. The current through the self-inductive conductor is, for steady currents, measured by an ammeter. A battery is connected between the first pair of extremities of the two conductors and the lever of the key; the battery-circuit is consequently open when the key is open, and closed when the key is closed. The current through the battery is regulated by a rheostat.

In order to make a measurement, the key is first closed, and the rheostat is adjusted to give a convenient current as read by the ammeter in series with the self-inductive conductor. This current is observed. For the second operation, the trigger of the key is released: this breaks the battery-circuit, and simultaneously puts the ballistic galvanometer in series with the two conductors. The corresponding "throw" of the ballistic galvanometer, resulting from the momentary induced E.M.F., is then observed. Finally, a relation is found which determines the self-induction of the given conductor, in terms of these two measurements and the known resistances. In the paper this relation is wrongly stated; self-induction appears as a resistance, which is impossible. More correctly: the required self-induction is proportional to the quantity of electricity discharged through the ballistic galvanometer at the second operation, divided by the steady current measured in the first, and multiplied by the resistance of the circuit containing the two conductors in series with the ballistic galvanometer and the ammeter. The limits of accuracy depend very much upon the perfect working of the key, since if it does not release the two contacts simultaneously the galvanometer is deflected by a fortuitous current. R. A.

288. *Induction Coils.* **B. Walter.** (Annal. Phys. Chem. 62. pp. 300–322, 1897.)—The author studies the form of the discharge by means of the magnetically displaced phosphorescent patch used by Braun. He finds that, apart from the losses of electrical energy

due to the spark at break, to magnetic and dielectric hysteresis, and loss in heating the circuit, the maximum value of the secondary E.M.F. in an induction-coil is directly proportional to the maximum intensity attained by the primary current and to the square root of the inductance of the secondary coil, and inversely proportional to the square root of the capacity in the primary circuit. Since it is easy to raise the intensity of the current at make, it is important to regulate the interruptor so as not to break down the insulation of the secondary. E. E. F.

289. *New Induction Coil.* (Elect. World, 31. p. 98, 1898.)—This is a description of an induction-coil suitable for Röntgen-ray work which has recently been constructed by Messrs. Rochefort and Wydts. In their transformer the primary is the same as that of a Ruhmkorff coil, with a laminated core on which is wound a double layer of coarse wire leading out to binding-screws. A tube surrounds the primary for its whole length. The secondary spool is comparatively short, and is placed around the middle of the primary coil. It rests between annular discs of glass supported by a wooden block. The two terminals of the secondary coil are attached to two screws inserted in the openings of two glass stoppers. The wires and leads are surrounded by a hydrocarbon insulator. The apparatus is constructed to give a discharge of 20 to 22 centimetres in length with 3·3 amperes at 6 volts applied between the primary terminals. W. G. R.

290. *Phase-meter for Alternating Currents.* **J. Tuma.** (Berlin. Akad. Sitzber. 106. pp. 442–452, 1897.)—The instrument consists of two coils, about 15·5 cms. and 18 cms. respectively in diameter, and 3 cms. wide, placed with their planes normal to each other and the axis of one of the coils in the magnetic meridian. At the centre of the coils is suspended a carefully annealed needle of soft iron, whose deflection is a measure of the phase-difference between the two currents traversing the coils of the instrument. Let I_1 and I_2 denote the two currents, c_1I_1 and c_2I_2 the maximum values of the magnetic fields due to them, ϕ the angle of phase-difference, ψ the angle between the needle and the normal to the coil whose axis lies in the magnetic meridian, and H the earth's horizontal component. The author shows that

$$\tan 2\psi = \frac{2c_1c_2I_1I_2 \cos\phi}{c_1^2I_1^2 - c_2^2I_2^2 + 2H^2}.$$

By making $I_1 = I_2$, and winding the coils so that $\frac{c_1}{c_2} = 2{\cdot}4142$, the term involving H may be neglected, and the formula becomes

$$\cos\phi = \tan 2\psi.$$

For securing exact equality of currents, the author uses a somewhat complicated bolometric arrangement. The use of the instrument is illustrated by some measurements made with it of the power-factor of a transformer at various loads. In its present state the instrument is far from being a commercial one; but the author hopes to reduce it to that form. A. H.

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291. *Use of Imaginary Quantities in Alternate-Current Problems.* **P. Janet.** (Écl. Électr. 13. pp. 529–531, 1897.)—If A be any alternating function of which the phase is ϕ, it may be represented by the formula

$$[A] = A(\cos\phi + i\sin\phi).$$

If the electromotive force expressed in this form be [E], [I] the intensity, we have $[I] = \frac{[E]}{r - is}$, where r is the ohmic resistance, $r - is$ the impedance.

M. Janet proposes to extend the principle as follows:—If E be the effective E.M.F. of an alternating generator,

$$[E] = E(\cos\phi + i\sin\phi).$$

If the generator be traversed by a current I with phase ϕ',

$$[I] = I(\cos\phi' + i\sin\phi').$$

The real part of [E] is $E\sqrt{2}\sin(\omega t - \phi)$, that of [I] is $I\sqrt{2}\sin(\omega t - \phi')$. The energy is actually $EI\cos(\phi - \phi')$. We ought to find that [E] [I] has for its real part $EI\cos(\phi - \phi')$. In order that this may be so, we must proceed according to the following rule, namely, use $-i$ instead of i in one or other of the two factors [E] and [I], and then take the real part.

M. Janet then gives an example:—E_1 being the effective E.M.F. of a generator, E_2 that of a motor; the phase of the latter is θ_1. The total E.M.F. is

$$E_1 + E_2(\cos\theta + i\sin\theta),$$

and for the current,

$$[I] = \frac{E_1 + E_2(\cos\theta + i\sin\theta)}{r - is}.$$

Then, according to the rule above found, the electric power given by the motor is

$$-E_2(\cos\theta - i\sin\theta)\frac{E_1 + E_2(\cos\theta + i\sin\theta)}{r - is},$$

of which the real part is

$$-\frac{E_1E_2(r\cos\theta + s\sin\theta) + rE_2^2)}{r^2 + s^2},$$

a known formula. S. H. B.

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292. *Alternate-Current Problems.* **C. F. Guilbert.** (Écl. Électr. 14. pp. 69–70, 1898.)—Referring to the work of M. Janet, the author points out that Steinmetz had calculated the real part of [EI] thus, writing

$$E=a+b\sqrt{-1}.$$
$$I=c+d\sqrt{-1}.$$

Steinmetz gets for the real part of $\overline{EI}$, not $ac-bd$ but $ac+bd$, which agrees with Janet's rule. Steinmetz also uses $P=\rho E^2$, where ρ is the conductance $\frac{r}{r^2+s^2}$. S. H. B.

293. *Change in Length by Magnetisation.* **B. B. Brackett.** (Phys. Rev. 5. pp. 258–284, 1897.)—The paper contains an account of some careful experiments on the permanent and temporary elongations (+ve and −ve), produced by fields up to about 300 units, of soft iron and pianoforte wires. On the hypothesis that when iron is magnetised, a *mechanical* compressive force is produced equal to $B^2/8\pi$, or perhaps to $(B-H)^2/8\pi$, the author calculates what portions of the elongations are due to purely magnetic action.

Tables and curves give the reader a rapid comprehension of the experimental results; but, owing to no fault of the worker, no brilliant generalisations have been deduced. A. Gs.

294. *Magnetic Properties and Chemical Composition of Iron.* **B. S. Summers.** (Soc. Chem. Ind. Journ. 16. pp. 998–1002, 1897.)—If the proximate analysis of iron by microscopic and other methods could be carried out more completely, it would doubtless be possible to establish relations between its physical properties and its proximate composition. The author has examined the influence more especially of non-metallic impurities on the magnetic permeability and hysteresis of iron. High permeability and low hysteresis usually, but not invariably, accompany each other. Experiments with cast-iron were difficult to interpret owing to the numerous impurities; special samples of cast-iron were therefore prepared with varying quantities of silicon and phosphorus. These contained about 2·5 per cent. of combined carbon and mere traces of graphitic carbon. Comparisons of their magnetic permeability show that the presence of silicon up to 3·66 per cent. has no marked effect, the same being true of phosphorus between 0·269 and 1·766 per cent. In this series of mixtures those samples containing least carbon had the highest permeability. Microscopic examination showed that the carbon was present mainly in the form of carbide. The presence of manganese in quantities less than 1 per cent. has also a very small effect on the magnetic permeability, especially when much carbon is present; the small influence noticed appeared to be due to the effect of the manganese in increasing the amount of combined carbon. The same is true of sulphur; the experiments were made with a semi-steel (con-

taining 40 or 50 per cent. of steel-rail scrap), in which the carbon was present mainly in the graphitic form. This metal contained about 2 per cent. of carbon, and the addition of more than 0·13 per cent. of sulphur made the metal very white and hard. The addition of 0·75 per cent. of silicon to this steel had no appreciable effect on its permeability; the total silicon was, however, always above 3·75 per cent., so that the variations tried did not affect the condition of the carbon. Although the increase of the silicon had no effect on the permeability, it diminished the hysteresis-loss very appreciably. When more than 1 per cent. of phosphorus is present, a further increase has no effect on permeability or hysteresis. The influence of both the silicon and the phosphorus appears to be indirect and due to their effect on the condition in which the carbon exists. This latter is the main factor to be considered; in general, a low percentage of carbon is accompanied by high permeability and low hysteresis-loss; but this is not always so, and the author supposes that the permeability is mainly affected by some special form of combined carbon, probably Ledebur's "hardening carbon"—the Martensite of the microscopists. Graphite appears to be inert, merely giving the metal a more open texture and lesser density; if it could be removed without increasing the combined carbon, the permeability would be higher. Micro-photographs showing the structure of several of the samples examined are given. In conclusion it is pointed out that the physical state of the metal may be of importance. An iron, almost free from carbon, may have a comparatively low permeability which will be changed to an unusually high one by annealing. This may be due to the removal of an internal stress or to the existence of an allotropic modification of iron. Notwithstanding this, the magnetic properties may often be calculated with fair accuracy from the chemical composition. T. E.

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295. *Magnetic Properties of Basalts.* **F. Pockels.** (Annal. Phys. Chem. 63. pp. 195–201, 1897.)—Rectangular rods of various specimens of nepheline basalt were tested by the magnetometric method. The general appearance of the magnetisation-curves is the same as in soft iron. Both the temporary and the remanent magnetisations increase more rapidly than the field at first, and afterwards less rapidly. The ratio of the remanent to the temporary magnetism increases at first with the field, but then becomes constant, and finally decreases. In the basalts containing the larger magnetite-crystals, the remanent reaches its maximum sooner than in the others. The magnetic properties of basalt may be used for an approximate determination of the current intensity of a lightning flash. Certain outcrops show an irregular and purely local magnetisation which can only be due to discharges of atmospheric electricity. Cutting rods out of these rocks, and determining the field necessary to produce the permanent magnetisation they actually possess, it is only necessary to have some idea of the distance at which the lightning passed to be able to gauge its current strength.

As a rule, it may be assumed that the discharge passes along the surface of the rock. Sometimes a damaged tree will give some indication. One such rough estimate led to a minimum value of 2900 amperes for the current intensity. Three specimens obtained from the neighbourhood of damaged trees gave 6400, 6600, and 10,800 amperes respectively, which are probably still too small.
E. E. F.

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296. *Concussion and Magnetism.* **C. Fromme.** (Annal. Phys. Chem. 63. pp. 314–323, 1897.)—Electric oscillations do not influence the susceptibility for permanent magnetism, either in an iron wire or a tube filled with iron-filings, although they may change the electric conductivity within wide limits. On the other hand, a large modification of the magnetic moment of the coherer may be without influence upon the electric conductivity. The change of electric conductivity takes place between the filings, the change of magnetisation within them. Electric discharges passing *through* the wire or the tube affect the magnetisation as concussion does. Concussions applied before magnetisation cannot, even if very numerous, produce the minimum susceptibility for permanent magnetism. This can only be attained by repeated alternation between concussion and magnetisation. On concussion the permanent moment always falls to the same amount, whatever the susceptibility. The loss of moment by concussion decreases as the alternating process is repeated, until the minimum susceptibility is attained. But in every case, the loss by concussion is proportional to the initial permanent moment. E. E. F.

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297. *Shielded Conductors.* **W. A. Price.** (Elect. Rev. 42. pp. 61–63 and pp. 68–69, 1898.)—This is an explanation why a conductor buried in the iron of a slot-wound armature experiences very little mechanical force, though it is equally as efficient in developing electromotive force in a dynamo, as if it were exposed on the surface of an ordinary drum armature, and has just the same effect in producing torque in a motor. The explanation given is that in a slot-wound armature the conductors are so shielded by the iron body in which the slots are cut, that only a very small part of the total magnetic flux passes through them at any given instant, and the force acting on the conductor is correspondingly small; while at the same time the total flux cut by any conductor in the course of the revolution of the armature is not affected. It is at the same time stated that the field in the body of the conductor is extremely weak, but as the armature is rotated the lines of flux are carried across the conductor, moving slowly in the mass of iron but flashing across the slot at great speed. Another point discussed is the comparative freedom from eddy currents in the conductors of slot-wound armatures, but no explanation of this is given. W. G. R.

298. *Magnetic Screening.* **H. Du Bois.** (Berlin. Phys. Gesell. Verh. 16. pp. 180–182, 1897.)—This is a preliminary communication on the magnetic protection which single or double shell cylinders or spheres, whose shells are separated by layers of non-magnetic materials, afford to objects within or without the spheres. For a given weight, the degree of protection depends upon the ratio of the radii of the spheres and intermediate layers. The theoretical results have been confirmed for simple spheres by experiments with iron filings, and for multilamellar spheres by experiments on the deflections of magnetic systems. The multilamellar spheres prove much more effective than simple shells. As regards the screening of objects at a distance, the formulæ are, strictly speaking, applicable only to cylinders of infinite length; but conclusions may be drawn as to cylinders whose length is not less than twice the diameter. A method of determining the permeability of lamellæ for transformers, etc. has been deduced; and the paper further concerns the screening of wires within armoured couples or in the perforations of dynamo armatures. H. B.

ELECTRO-CHEMISTRY AND CHEMICAL PHYSICS.

299. *Possible Change of Weight in Chemical Reactions.* **F. Sanford** and **L. Ray.** (Phys. Rev. 5. pp. 247–253, 1897.)—The authors have repeated Landolt's work (Zeit. Phys. Chem. 12. p. 1, 1894, and Ibid. 12. p. 31, 1893), but using the reduction of silver from an ammonia solution of the oxide by means of grape sugar instead of the reaction between silver and ferrous sulphate as used by him. They conclude that while their weighings show much greater irregularities than those of Landolt, they are still accurate enough to make it extremely improbable that the reaction was accompanied by any such change of weight as was observed in the similar reaction used by him. S. R.

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300. *Molecular Volumes of Gases.* **A. Leduc.** (Paris. Soc. Franç. Phys., Bull. 104. pp. 1–3, 1897.)—Having ascertained as precisely as possible the densities of 23 gases in the pure state, from Stas' molecular weights he calculates the molecular volumes at 0° and 76 mm. as compared with those of a perfect gas. His result is that at any temperature T° and pressure p cm. the molecular volume for normal gases is

$$v=1-[y+(e-1)z+(e-1)^2u]10^{-4},$$

where $y=72\chi^4-130\chi^3+172\chi^2-83\chi+12\cdot3$, χ being Θ/T, where Θ is the critical temperature; e is p/π, where π is the critical pressure; z is $101\cdot4\chi^4-220\chi^3+266\chi^2-119\chi+16\cdot9$; $u=20\chi(\chi-1)$. For more compressible gases (CH_4, C_2H_6, NH_3, CH_3Cl), y, z, and u must be multiplied by 1·16: for less compressible (H_2S, PH_3), y must be multiplied by 0·93, and z and u by 0·84. The coefficients of dilatation are also worked out in detail; and the conclusion is reached that nitrogen obeys Boyle's law at 100°, carbon dioxide at 620°, and sulphurous anhydride at 985°. A. D.

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301. *Calcium Carbide as a Reducer.* **H. Moissan.** (Écl. Électr. 14. pp. 120–121, 1898.)—Most metallic oxides are reducible by calcium carbide: some, such as those of lead, copper, bismuth, and tin, at a dull red heat; but the majority only by the liquid carbide at the temperature of the electric furnace. The metals of the first class are liberated in the free state, but with the more refractory metals carbides are formed, uncontaminated, however, with calcium. In this manner, with a current of 900 amperes at 45 volts, well-defined crystalline carbides of aluminium, manganese, chromium, molybdenum, tungsten, and titanium have been prepared. The excess of calcium carbide is readily removed by water or dilute acetic acid. Calcium silicide (carborundum) is readily obtained in colourless, or at the most faintly coloured,

crystals in this way by fusing an equimolecular mixture of powdered quartz and calcium carbide, and the process is likely to become of commercial importance. J. W.

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302. *Copper-Glucinum Alloys by the Electric Furnace.* **P. Lebeau.** (Écl. Électr. 14. pp. 121–122, 1898.)—On heating oxide of glucinum with charcoal in an electric furnace, glucinum carbide is formed but not metallic glucinum; but on subjecting to the same treatment an intimate mixture of the oxides of glucinum and copper, obtained by evaporating together and igniting solutions of the nitrates, an alloy of glucinum and copper is obtained, free from metallic carbides. The ingots thus prepared show a rose-red fracture, but are not homogeneous, and readily yield on heating an almost colourless product containing from 5 to 10 per cent. of metallic glucinum. The 10 per cent. alloy is almost colourless, the 5 per cent. alloy yellowish. The latter is malleable, both cold and hot, and is readily worked with the file and polished. It does not tarnish in the air, but is slightly discoloured by sulphuretted hydrogen, and is readily soluble in nitric acid. Alloys containing from 1·3 per cent. of glucinum downwards are of a golden yellow or deeper colour; they are very easily worked, and very sonorous. J. W.

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303. *Activity of Electrolytic Gases.* **F. Winteler.** (Zeitschr. Elektrochem. 4. p. 342, 1898.)—It is often assumed that electrolytic hydrogen, oxygen, and chlorine are more active chemically than the gases prepared by chemical methods, and it cannot be denied that electrolytically prepared mixtures of hydrogen and chlorine, and even of hydrogen and oxygen, have been known to explode without apparent cause. Bunsen showed years ago that the spontaneous explosion of the hydrogen-chlorine mixture does not occur outside the generating cell, and that it is not due to the presence of hydrochloric acid, since a similar chemically prepared mixture is far less easily fired after saturation with hydrochloric acid gas. As the explosions undoubtedly occur only in the generating vessel, the author thinks that it is unnecessary to assume that the gases are in a specially active (*i. e.* atomic) condition, but that the activity is due to hydrogen absorbed by the kathode. A palladium kathode, for example, saturated with hydrogen and then washed and dried, heats so rapidly in the air as to ignite gun-cotton in a few seconds, and platinum behaves in a similar manner, the temperature rising sufficiently to detonate a hydrogen-oxygen mixture when a kathode of this metal is not completely immersed. Numerical data are promised. J. W.

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304. *Hardening Oxide in Accumulators.* **S. Hammacher.** (Écl. Électr. 14. pp. 117–118, 1898.)—Four methods are described of obtaining a hard deposit of lead oxides, and thus enabling the weight of the supporting plates to be diminished. In the first, a mixture of the oxides with coal-tar residues (pitch) and alcohol or

light petroleum is used; but the resulting mass, although not disintegrated by dilute sulphuric acid, has an unduly high resistance. In the second, the oxides are ground up with ethyl butyrate; but in this case the lead combines with the butyric acid on drying the plates, and the hydrides and oxides of carbon disengaged on passing the current partially disintegrate the plates. In the third, the oxides are mixed with glycerine; but here, although stable plates are obtained, the excess of glycerine has to be destroyed by the addition of potassium permanganate to the electrolyte, and thus the cost becomes prohibitive. In the fourth, the litharge or red lead is mixed with picoline, lutidine, etc. (bone-oil), and dried in a stove. The plates thus obtained are stated to be very hard, stable, efficient, and reasonable in price. J. W.

305. *Electrolytic Zinc.* (Eng. 65. pp. 85–86, 1898.)—Processes for the electrolytic reduction of zinc have not, as yet, been very successful, partly owing to the comparatively low value of the metal, and partly to the small demand for pure zinc. The Broken Hill ore of New South Wales is essentially a mixture of the sulphides of lead, zinc, and silver, which is not resolvable by ordinary metallurgical processes. But by the Ashcroft electrolytic process the zinc, after dissolution in ferric sulphate solution (obtained at a later stage by the action of iron anodes on the zinc sulphate thus produced) can be precipitated electrolytically, and the residual lead and silver then smelted in the ordinary manner. It is doubtful, however, whether the method will pay commercially, the result of a few months' working having been less favourable than was anticipated. In the Siemens-Halske process, also being tried in Australia, sulphuric acid or acid zinc sulphate is substituted for the ferric sulphate of the Ashcroft process, but the results obtained on the large scale have not as yet been published. In Dieffenbach's process, which is being successfully applied at Duisberg, in Germany, to zinciferous iron pyrites, the ore is simultaneously chlorinated and roasted; the zinc is then dissolved out with the effluent zinc chloride from the depositing vats, and the solution electrolysed. Taking the cost of an electrical H.P. hour at 1*s.* 10*d.*, as at Niagara and in Switzerland, and assuming an energy-efficiency of 33 per cent., the energy alone required per ton of zinc reduced costs £3 5*s.* 6*d.*; and to this must be added the cost of working, and charges for interest, depreciation, and royalties; so that there does not appear to be much margin for profit. In the processes for "galvanising" iron the texture of the deposit, which is of course all-important, is somewhat difficult to control. For ordinary work the usual dipping process is not, therefore, likely to be superseded; but in special cases, by paying attention to the current density, to the concentration and composition of the solution, and to the preparation of the article to be coated, a particularly smooth and tenaciously adherent coat of the metal may be obtained. J. W.

306. *Purification of the Electrolyte in Copper Refining.* (Electn. 40. pp. 523–524, 1898.)—This is an abstract of a paper by **T. Ulke** in a recent number of the 'Zeitschrift für Electrochemie.' At the Baltimore Copper Co. about one-fifth of the electrolyte is removed from time to time, and pure copper sulphate solution is added so as to adjust the strength of the electrolyte in copper sulphate to its normal value whilst reducing the amount of impurities. From the liquor removed, $CuSO_4$ is obtained and sold, the final or mother liquors being precipitated with iron scrap to recover the remaining 2–3 per cent. of copper. At the works of Guggenheim Bros., Perth Amboy, a method analogous to that of K. and H. Borchers is employed, in which the liquid of each tank is simultaneously circulated and aërated by a jet of air at a pressure of 3 or 4 lb. per sq. in. blown into a vertical tube open at top and bottom so as to allow the electrolyte to enter below and to be ejected above. In addition to this the electrolyte needs periodical replacement, the liquor being run into lead-lined vats and boiled with scrap-copper with free access of air. In this manner the free acid is neutralised, and the solution so enriched in copper sulphate that it can be readily crystallised to yield this salt, which is deposited on lead strips hung across the crystallising tank. The mother liquor contains almost the whole of the antimony and arsenic together with a small quantity of copper. The latter is precipitated by iron plates on which the arsenic is afterwards deposited in the form of a black precipitate containing about 60 per cent. As. From this, crude Cu or arsenic compounds, such as Scheele's green, Paris green, or white arsenic can be obtained. In the Chicago Copper Refinery, the bulk of the copper-sulphate is obtained by crystallisation, and the mother liquor is boiled down to a point at which both copper sulphate and arsenious acid crystallise out. The mixture is extracted with just enough water to dissolve the copper sulphate, which, being thus fairly freed from arsenic, is returned to the vats. Other methods include boiling the liquor with metastannic acid to precipitate As; filtration of the liquor through a layer of cuprous oxide to precipitate most foreign metals as hydroxides, and the oxidation of other impurities, notably iron, by aëration; other impurities, *e. g.* arsenic, being precipitated as ferric arseniate. A good method is to electrolyse the liquors from the vats with a current-density so high that all impurities save iron are deposited pell-mell with the copper, using sheet-copper kathodes and lead anodes. This is of advantage where the metal, although impure, is more saleable than copper sulphate. The liquor, free from As and Sb but still containing Fe, is brought up to strength with fresh $CuSO_4$, this process being repeated until the percentage of Fe becomes too great, when the liquor is finally worked up for copper sulphate. C. K. F.

GENERAL ELECTRICAL ENGINEERING.

307. *Accumulator Plates.* **F. W. Greengrass** and **S. R. Dockings.** (Écl. Électr. 14. pp. 70–71, 1898.)—Lead spirals, cut on a lathe from a cylinder of the metal, are pressed flat on either side of a rigid support, and soldered in position. The plates thus constructed are then "formed" in the usual manner. J. W.

308. *Accumulator Plates.* **F. Grunwald.** (Écl. Électr. 14. p. 71, 1898.)—Two grids of the usual type are clamped on either side of a third, to which the small squares of metal, usually cut away, are left attached by one side and bent over at right angles to form supports for the oxide when the cell is "formed." J. W.

309. *Supporting Accumulator Plates.* **G. Fabro.** (Écl. Électr. 14. pp. 71–72, 1898.)—Two clamps are described. The first, which is intended for use in mechanical traction, consists of two blocks of wood, connected by two bolts passing through stout indiarubber buffer-cylinders, allowing a certain amount of play. In the second, which is intended only for stationary accumulators, connection is made through sliding-rods, carrying hinged jaws on which the plates rest and which grip the tighter, the heavier the load. J. W.

310. *The "Hatch" Secondary Battery.* (Electn. 40. pp. 381–382, 1898.)—The usual paste of peroxide is plastered on porous grids of baked china-clay or the like, and the plates thus made are built up into blocks with sheets of lead, the whole being bound together by thick outer slabs of insulating material bolted or clamped to each other, and the alternate lead plates connected up in the usual way. The unpasted sides of the porous grids being channelled to allow of the escape of gases, and it being practically impossible for the paste to break away, an unusually long life is said to be secured for the cell, and the risk of injury from excessively rapid charge or discharge considerably reduced. The internal resistance is said to be reasonably low. J. W.

311. *Lathe for Commutator Turning.* **M. Aliamet.** (Électricien, 15. pp. 57–58, 1898.)—This is an illustrated description of an arrangement for turning up the commutator of a dynamo without the necessity of taking the armature from its position between the field-magnets. The arrangements, with complete set of turning tools, are constructed by Messrs. Honeywood and Austin of London. W. G. R.

312. *Electrical Steering Gear.* **M. Pfatischer.** (Elect. Engr. N. Y. 25. pp. 68–69, 1898.)—An arrangement is described for electrically controlling the valve-gear of a steering engine of the ordinary type. The apparatus consists of a forward-rheostat near

the bridge, and an after-rheostat in the steering-engine room, together with a ½ H.P. electromotor and a motor-generator. The rheostats are joined across the ship's electric circuits; from a movable contact-arm on the forward-rheostat a single balancing-wire is led, through the field circuit of the generator, to the corresponding arm on the after-rheostat.

The movable arm of the forward-rheostat is geared to the steering wheel, so that when the latter is rotated the arm is moved and an electric balance is disturbed, causing a current to flow in the balancing-wire: this excites the field of the generator, which then supplies current to the ½ H.P. motor. The latter is geared to the valve of the engine and the movable arm of the after-rheostat; both are set in motion, and continue to move until the electric balance is restored, when the motor comes to rest. No electric circuits are interrupted, so that there is no sparking; and the motor runs either way, according to the motion of the steering wheel. To prevent accident, the motor actuates the valve through a spring attachment. No diagram of connections is given.

A. H. A.

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313. *Effect of Vibrations on Thomson Meter.* **E. O. Keenan.** (Ind. Élect. 7. pp. 45–48, 1898.)—This is an account of experiments made in the laboratory of the Compagnie parisienne de l'Air Comprimé, in order to ascertain the effect of vibrations on the indications of Thomson meters, and the best means to overcome this. The meters tested were fixed against a thin partition, to which was also attached a trembling bell-movement, in order to give vibrations of constant frequency and amplitude.

In the absence of vibration, the meter follows the law $y=a+bx$; the effect of vibration is to displace the line parallel to itself, changing a from a negative towards a positive value, while b remains constant. When a, which depends on the starting current and friction of the mechanism, is negative, the meter does not begin to move until $x=-\frac{a}{b}$; when a is positive the meter runs without load, "on the shunt," which leads to dissatisfaction on the part of the consumers. To avoid this, it is usual to tighten the brushes, so as to give a such a large negative value that it never becomes positive under the action of vibration; but this leads to a considerable loss to the Supply Company, especially in the case of large meters, as the meter does not start unless the load reaches 1 or 2 per cent. of the maximum, and runs slow for small loads. The effect of this is illustrated by diagrams showing the percentage slowness at different loads for several values of a.

The method found to be most effective in shielding the meters from vibrations was that of mounting the meter on indiarubber buffers (*amortisseurs*), provided with brass caps for attachment to the meter and to a horizontal supporting bracket.

The method of testing and the apparatus used are described, and the following results given:—In a test of a 25 a. 110 v. meter, the change in *a* without the buffers amounted to 12 watts; the use of buffers reduced the change to 1·77 watts. A similar test of an 11000 watt meter gave 44 watts and 2·4 watts without and with buffers respectively; the buffers in this case were thicker.

The author has found it possible in practice, with the use of buffers, to adjust large meters to start with 0·005 of their maximum capacity, without risk of running on the shunt. Further, the wear of pivots and sockets, and sparking at the brushes, are greatly reduced. A. H. A.

314. *Automatic Cut-in Switch.* (Electn. 40. pp. 391–392, 1898.) —This is a description of an automatic switch for bringing extra transformers at sub-stations into action as the load increases. One transformer is always connected to the mains: to each of the others is attached one of these "Walton" switches. The principle is as follows:—Above the switch, and attached to it, is a heavy mass of metal which is held in position by an electromagnet device actuated by solenoids traversed by all, or a portion, of the current passing through the permanently-connected transformers. When this current exceeds a certain value, the heavy mass is released, and in falling drives home the switches necessary to bring a second transformer into action. The arrangement is such that the primary switch is not closed until after those belonging to the secondary circuit, thus avoiding a rush of current in the primary circuit. These switches are in use at the Bayswater sub-station of the Metropolitan Electric Supply Company. It is noticeable that the switch will not automatically cut out the transformer when the load falls. W. G. R.

315. *Magnetic Cut-out.* **M. Aliamet.** (Électricien, 14. pp. 385–387, 1897.)—These cut-outs are operated briefly as follows, viz.:— The knife or other movable contacts are mounted on an arm which is acted upon by a spring so as to normally break the circuit. This arm is held in position to complete the circuit by means of a detent consisting of a hook on the arm engaging a hook on one end of a pivoted lever. The other end of this lever is acted upon by the core of an electromagnet in series with the circuit to be protected, so that, when the current exceeds a predetermined value, the hooks will be disengaged from each other and the circuit broken by the action of the spring above mentioned. C. K. F.

316. *Schuckert Indicator for Broken Circuits.* **M. Aliamet.** (Électricien, 15. pp. 38–39, 1898.)—In polyphase installations it is necessary that the load and power-factor of the different phases should be equal. When the circuit of one of the phases is broken, there is a want of equilibrium in the distributing system, and there occurs an inadmissible fluctuation in the pressure of the other phases. The Schuckert device is for the purpose of indicating

when the circuit of one of the phases has been broken. It is based on the principle of the differential balance, already used on three-wire continuous-current circuits, in which case two solenoids having the same number of turns are connected across the two sides of the three-wire system. Into these solenoids dip two similar soft iron cores suspended from the arms of a balance. When the distributing system is out of balance, the attraction will be greater on one core than on the other, and the consequent tilting of the balance-beam constitutes a signal. In the Schuckert device, three laminated cores are used, quite similar to one another and fixed to the three corners of a triangular support suspended from its centre. The three electromagnets are each connected in the circuits of the three phases, and any weakening of the current in any of the phases will cause the triangle to tilt, and a signal can be given by a system of electrical contacts. This device may also be employed in a two-phase system having a common return. In this case the solenoid connected in the return circuit should have $1{\cdot}414 = \sqrt{2}$ times less turns than for the other solenoids.

This device has been successfully employed in Germany.

L. J. S.

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317. *Montaux Multiphase Fire Cable.* (Elect. Rev. 42. p. 60, 1898.)—Among the devices common in the United States for automatically locating and announcing an outbreak of fire, thermostats are employed for automatically closing an electric circuit when the local temperature passes a certain point. These thermostats are scattered throughout a building in various places; and the disadvantage exists that, if the fire should start at a point intermediate between two thermostats, there would be more or less delay until the temperature reached the proper degree to operate the alarm. The above system of fire cable consists of the logical development of the usage of the thermostat; and instead of the use of a number of isolated instruments, the whole wire itself is so sensitive that the mere heat of a lighted match applied to any point of the wire will cause the metal to fuse and ring an alarm.

The cable is made up of an inner copper wire covered with a metal which fuses at the low temperature of 374°, the copper being used to increase the conductivity. The fusible metal is covered with a suitable insulation, and over this again is wrapped a series of smaller wires with insulation between them, the whole being covered with an outer protective wrapping. One of the outer wires serves for the fire alarm, another the burglar alarm, another may be used for the servants' call, and the remainder for various purposes. A fire in the neighbourhood of the wire will fuse and expand the inner fusible coating and force it through the insulation into contact with the overlying return wire, thus closing circuit and turning in an alarm.

A valuable feature of this cable is that it forms an effective burglar alarm; for if a burglar should attempt to destroy the ordinary window-alarm by breaking the window-glass and cutting the wires, the pliers will form a metallic connection between the inner and outer wires of the cable and close the circuit. To avoid error in connecting up the return wires, they are made in different colours.

Considering the complicated nature of the cable and the duty that it performs, its bulk is said to be remarkably small and attracts no more attention than ordinary house-wiring. For detecting a fire, due to spontaneous combustion in the coal-bunkers or hold of a ship, the wires are laid in pipes which protect them from rough usage but leave them exposed to the action of heat. An important feature in the utility of this cable is the rapidity of its action upon the outbreak of a fire. L. J. S.

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318. *Electrical Cooking.* **J. P. Jackson.** (Amer. Instit. Elect. Engin. 14. pp. 397–402, 1897.)—The tests of electrical cooking apparatus detailed in this paper were made with the hope of obtaining a method of cooking that would be satisfactory, with a minimum risk of fire, in a college which is supplied with electricity for lighting and power at a pressure of 110 volts. Experiments were carried out with the following apparatus:—

1 oven, 13″ × 9″ × 18″, having 3 heats, of 3, 10, and 17 amperes respectively;
3 stoves, of 2, 4, and 5 amperes respectively;
2 flat-irons, of 1·5 and 6 amperes capacity;
1 broiler, of 12 amperes capacity;
1 curling-iron, of ½ ampere capacity.

In all these appliances the heating-coils are so arranged that the energy is largely concentrated at useful points. They are also supplied with supports and bases which are poor conductors of heat.

The efficiencies of the two larger stoves were obtained by heating two pounds of water to the boiling-point and measuring the power supplied by a calibrated wattmeter. The efficiencies, considering the ratio between the amount of heat absorbed by the water and the amount received by the stoves, were:—

For the larger, or No. 1	48·9 per cent.
For the next size, No. 2	43·1 „

When it is desired to boil water, the best plan is to place an immersion-coil in a properly heat-insulated pot; such an arrangement should give an efficiency of 90 to 100 per cent. The cooking apparatus was used for cooking meals for a family of six during several weeks. The following figures may be taken as a fair average of the whole period; all costs being estimated on a basis of 10 cents per kilowatt-hour:—

Breakfast	1·355 kilowatt-hours.	Cost, 11·46 cents.
Dinner	2·98 „ „	Cost, 29·8 „
Supper	8·39 „ „	Cost, 8·39 „

The author then states the energy required for different kinds of foods; such as bread, meat, soup, etc. The result of a whole series of meals was a cost for electricity of 13·1 cents per meal. When the meals were cooked by means of coal burnt in a stove (No. 8, Othello coal stove), the results gave an average of 12·6 lbs. per meal, which at 5·00 dollars per ton gives a cost of 3·15 cents per meal, showing the cost of cooking by coal to be about 19 per cent. of the cost of cooking by electricity.

The author also gives data relating to the cost of ironing by electricity.

The results of the cooking tests seem to indicate that, for the usual cooking of a family for the whole year, the expense would be larger than would be ordinarily acceptable notwithstanding the great advantages in other respects. The author considers that in a number of cases the utility of electrical cooking utensils should be great; for instance:—

(1) For light housekeeping, where coal, oil, gas, or gasoline are frequently used;

(2) An electrical stove of 300 to 400 watts, to replace the frequently-used alcohol flame;

(3) In the shop the glue-pot, solder-pot, brazing-iron, etc. can be heated advantageously by electricity.

Other cases are also mentioned.

The general results of the tests were of such a nature that the writer is warranted in the belief that if Central Station managers would more generally introduce such applications, a new call on their station capacity would develop, of which a large proportion would be during the light-load periods. L. J. S.

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319. *Enormous Electric Beacon.* (Elect. World, 31. pp. 96–97, 1898.)—There is at the United States lighthouse establishment at Tompkinsville, Staten Island, a gigantic electric beacon. The lantern consists of two lenses, each 9 feet in diameter, enclosing between them an electric arc of great power. In the central portion of each lens is a disc having two prismatic rings. Outside this are 190 prismatic segments so arranged that the light of the arc is totally reflected in each and thrown out in a practically non-divergent beam. In this way nearly all the light of the arc, which is estimated at 90,000,000 candles, is concentrated in two great beams 9 feet in diameter, directed towards opposite points of the horizon. The beams of light could be seen at a distance of 100 miles if placed in a sufficiently high tower.

The whole apparatus is floated on mercury, and is rotated by a powerful clockwork arrangement. The period of one revolution is 10 seconds; so that every point of the horizon is illuminated once every 5 seconds. The weight of the complete apparatus is about 20 tons. The lamps are arranged to carry carbons of from 15 to 60 millimetres in diameter. With 30 mm. carbons the arc takes a current of 60 amperes at 55 volts on an alternating-current circuit of frequency 140 cycles per second. W. G. R.

320. *Electric Grain Elevator.* **O. E. Dunlap.** (West. Electn. 22. pp. 62–63, 1898.)—The Great Northern R.R. Company's grain elevator is situated in Buffalo, N.Y., on the Blackwell Canal; the structure is 396 ft. long, 150 ft. wide, and 177 ft. high, and is built on a foundation of piles and masonry. There are sixty-six cylindrical steel bins, 85 and 60 ft. high, having a total capacity of 3,000,000 bushels. The building is equipped with ten inside legs 177 ft. high, each driven by a 50 horse-power motor, and carrying two rows of buckets; each leg handles 15,000 bushels of grain per hour. A 100 horse-power motor is used for driving fans and dust-collectors. Two conveyor belts, each 60 ins. wide, 740 ft. long, are driven by two 20 horse-power motors, and have a capacity of 40,000 bushels per hour each. Between the elevator and the canal are two railroad tracks on which run three marine towers, each having 32 wheels. Each tower carries a 100 horse-power motor, and is capable of elevating 20,000 bushels per hour: electrical energy is supplied by means of three trolley-wires 40 ft. from the ground. The towers are moved by means of a cable driven by a 50 horse-power motor within the building There are two railroad tracks on the north side of the building, and one within the latter; from these 400 cars can be shipped daily. The electrical energy is derived from Niagara Falls, at a distance of 30 miles; the generators, of 5000 horse-power each, supply current at 2200 volts, which is transformed up to 11000 volts and transmitted through six cables on the three-phase system. At Buffalo the pressure is reduced to 2200 volts in a transforming station, and again to 440 volts at the Great Northern elevator by means of two 600 horse-power transformers. The current is received as three-phase and used as two-phase. The main switchboard consists of nine panels, bearing the controlling apparatus for all the motors except those in the marine towers. The motors are of the Westinghouse induction type, six-pole, 440 volt, running at 500 revolutions per minute; they are without brushes, and therefore sparkless—an important feature on account of the presence of grain dust. Flexible cable, insulated with rubber, and supported by cleats, is used for the wiring. There are 420 lights, controlled from the ground floor, and from distributing boxes for groups of 10; these are on two-phase 104 volt circuits. The elevator was built by D. A. Robinson, under J. J. Hill, the President of the Great Northern R.R. Company, at a cost of about 500,000 dollars. A. H. A.

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321. *Volatile Oils in Boilers.* **W. H. Edgar.** (West. Electn. 22. pp. 63–64, 1898.)—In this paper the author points out that the action of kerosene and petroleum in cleansing boilers from scale is purely mechanical; the oil penetrates between the scale and the iron shell and loosens the former. On the other hand, it is decomposed in contact with the hot shell and carbonises the plates, causing blisters and roughening the skin of the iron. The

oil is volatile at moderate temperatures and passes with the steam into the pipes and engine cylinders, which it corrodes and blackens; it also injures joints and metallic packing.

In the discussion which followed the paper, the author stated that corrosion in the presence of pure water only is due to the formation of ferric hydrate; the action is less vigorous when the water contains salts of lime and magnesia. Crude tannin was highly recommended for preventing scale; tannin converts carbonates into tannates, but has no effect on sulphates. Pure tannic acid is too stable. Sugar is useful in converting sulphates into saccharates, which break up into other organic salts; a small quantity of slippery elm facilitates the reactions, as it contains soluble wood-starch, which makes the sugar and tannin less stable. The feed water should be analysed, and suitable proportions of sugar and tannin employed. These substances have no injurious effect on the boiler, steam-pipes, or packing. A. H. A.

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322. *Tests of Anthracite.* **J. L.** (Ind. Élect. 7. pp. 50–52, 1898.)—Some tests are given of English anthracite with Richards grates and of St. Charles coal. M. A. Laclance, prior to making the tests, experimented with Langer smoke-consumers and had six boilers fitted with them. The grates are formed by cast-iron plates perforated with conical holes. Under the plates are led jets of steam which create a forced draught to ensure complete combustion of the anthracite. St. Charles coal costs 28 francs a ton and anthracite 34 francs, including 7·2 francs duty and 3·5 for cartage. The mean of four tests of anthracite gives 7·787 centimes as the cost of energy per kilowatt-hour produced; and the mean of three tests of St. Charles coal with ordinary grates and smoke-consumers 7·382 centimes, or with Richards grates with a forced draught 7·458 centimes per kilowatt-hour. Anthracite is the cleaner and more satisfactory coal, and would be much used in Paris if the price could be reduced to 32 francs per ton, as may be the case on obtaining a direct service between Paris and Cardiff. W. G. R.

DYNAMOS, MOTORS, AND TRANSFORMERS.

323. *Three-Wire Dynamo.* **P. Girault.** (Écl. Électr. 14. pp. 204–208, 1898.)—This is a description of a three-wire dynamo to furnish 1400 amperes at 290 volts and at a speed of 300 revolutions per minute. The armature is drum-wound in parallel with a connector joining together the points of the winding, which are at the same potential. The winding consists of 400 bars of copper in slots round the periphery of the core, which is formed by circular sheet-iron stampings held together by insulated bolts. The winding is divided into two symmetrical parts relative to the mean point which corresponds to the neutral conductor in the distribution. W. G. R.

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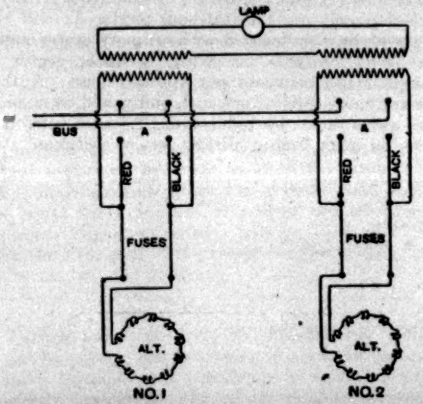
324. *Synchronising Alternators.* **H. E. M. Kensit.** (Electn. 40. pp. 478–479, 1898.)—The author gives methods of ascertaining whether, when running two alternators in parallel, the synchronising transformers are so connected that the alternators are in phase when the lamp is bright. There are three possible ways of connecting up the synchronising transformers: (1) each transformer with its primary across only one coil of the corresponding alternator; (2) each primary directly across the alternator terminals; and (3) one transformer primary across one alternator coil and the other primary direct across the other alternator terminals. Each of these three cases is discussed.—The second case, which is the simplest and the best, is as follows:—The arrangement is shown diagrammatically in the above figure. Let AA represent double-pole switches for connecting the machines to the



bus, No. 1 the loaded machine, and No. 2 the incoming machine. Take out the fuses of No. 2, or raise the brushes at the alternator and insert the bus-plug at A. If, then, the lamp is bright all is right for paralleling. If not, the leads to the synchronising transformer of No. 2 must be reversed. W. G. R.

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325. *Paralleling Alternators.* **G. W. Meyer.** (Elect. Runds. 15. pp. 24–25, 1897.)—The method described by the author is more particularly applicable to small alternators, and involves very simple apparatus. Let one terminal of the alternator which is to be thrown into circuit be connected to one of the bus-bars, and let its other terminal be joined to the other bus-bar through a resistance, across a portion of which is placed a telephone receiver. If the alternators give identical wave-shapes, it is obvious that no sound will be heard in the telephone when the machines are running synchronously and are in phase with each another. When this condition is reached the resistance may be short-circuited by a switch, and the alternator thus thrown into parallel with the other machines. A telephone receiver may also be used in connection with a synchronising transformer. A. H.

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326. *Alternate Current Induction Motor.* **C. P. Steinmetz.** (Amer. Instit. Elect. Engin. 14. pp. 175–207 and 407–412, 1897.) —This treatment is supplementary to previous writings by the author on the same subject. Two new terms are introduced, viz.: "torque efficiency" and "apparent torque efficiency." Torque efficiency is defined to be the ratio of the torque of the motor to the torque which it would give at the same power input if there were no internal losses in the motor. Apparent torque efficiency is the ratio of the torque of the motor to the torque which it would give at the same volt-ampere input if there were neither internal losses nor phase displacement in the motor. These torque efficiencies are of special interest in starting where the power efficiencies are necessarily zero; and the author considers the names preferable to the terms "torque per watt" or "torque per volt-ampere."

The paper contains curves connecting the power output with (1) efficiency, (2) apparent efficiency, (3) current, (4) power factor, (5) speed; (6) torque for (*a*) the best motor built for 40 or 60 cycles, (*b*) a high-resistance motor, (*c*) a high-resistance and high-admittance motor, (*d*) a high reactance motor, and (*e*) a high susceptance motor. A comparison of these motors with each other shows that a good motor (*a*) is characterised by high values of power factor, efficiency, and apparent efficiency at light loads as well as heavy loads, by fairly close speed regulation and low exciting current. *High resistance* is characterised by poor speed regulation, and lowering of the efficiency at heavy loads; *high reactance* by very good speed regulation, good efficiency at heavy loads, and low power factor and apparent efficiency at light loads; *high admittance* by high exciting current and poor power factor and apparent efficiency at light loads.

The author considers the effect of introducing additional resistance and reactance into the secondary windings, and concludes that by the use of additional resistance torque can be produced with the same current, power factor and torque efficiencies as correspond to the same torque when running; also the effect of additional negative reactance, or capacity, is to cause the torque and current of the motor to rise enormously. The question of an induction machine running with negative slip or acting as a generator is considered, and it is pointed out in the discussion that the same machine gives a considerably larger output electrically as a generator than it does mechanically as a motor.

The paper contains a useful reference table of the performances of three-phase and mono-phase induction motors. W. G. R.

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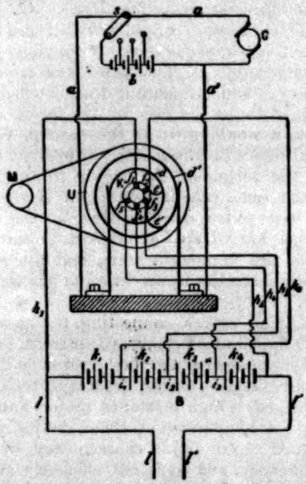
327. *The Transformation of Direct Currents.* **J. R.** (Écl. Électr. 13. pp. 558–559, 1897.)—This is a description of the Muller and Tudor commutator used in the transformation of continuous currents from low to high tension by means of accumulators. The arrangement is shown in the accompanying figure.



Muller and Tudor Commutator.

Two conductors *a*, *a'*, between which is placed a battery of accumulators *b*, are fed from the generator G through the brushes C and C′ of a commutator U whose collector-rings $d\,d'$ are rotated uniformly by a motor M. These rings have internal brushes which rub against the segments f_1, f_2, f_3, f_4, f_5 of the commutator K which are connected by the leads h_1, h_2, h_3, h_4, h_5 with a battery of accumulators B arranged in groups k_1, k_2, k_3, k_4, so that the leads h_1 and h_5 are connected to their extremities and the other three to the connectors i_1, i_2, i_3. The main leads from the battery are l and l' in the figure. By this arrangement it is seen that the battery B is charged in a parallel arrangement and discharged in series. The arrangement can evidently be adapted to a transformation from high to low tension in a similar manner.

W. G. R.

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328. *Electrolytic Rectifiers.* **J. Blondin.** (Écl. Électr. 14. pp. 293–298, 1898.)—In a discussion on the Pollak-Grätz rectifier the author gives a *résumé* of what had previously been done in this direction by other investigators as follows, viz.:—(1) The phenomenon on which these apparatus are based was discovered in 1857 by Buff (Ann. de Liebig, 52. p. 296, 1857), and rediscovered in 1875 by Ducretet (Comptes Rendus, 80. p. 280, 1874; Journal de Physique, 4. p. 84, 1875).—(2) The industrial application of cells with aluminium plates was first made by Ducretet for telegraphy; their application to the rectification of alternate currents was described for the first time by Hutin and Leblanc ('Étude sur les Courants Alternatifs et leurs applications industrielles,' 2nd part, chap. 10. p. 135, and French patent No. 215945, 1891). The apparatus has been studied from the theoretical side by Beetz (Wied. Ann. 2. p. 94, 1877) and Streintz (Wied. Ann. 32. p. 116, 1887; and 34. p. 751, 1888).

C. K. F.

POWER DISTRIBUTION, TRACTION, AND LIGHTING.

329. *Electricity in Municipal Engineering.* **R. B. Owens.** (Elect. World, 31. pp. 151–152, 1898.)—The author points out the economy to be effected by generating the power required for various municipal undertakings at one point, and distributing it by electrical means. In many places the supply of water is obtained from wells by means of isolated steam-pumping plants; the latter may be replaced by pumps driven by electromotors, electrical energy being supplied from a central generating station. If storage reservoirs are provided, the load may be regulated, so that during the daytime the pumps absorb most of the output of the station, while at night the pumps are stopped and the whole output is available for electric lighting. Sewage disinfection by the Hermite or Woolf process may be carried on and regulated in the same way, so that the load on the generating station is practically constant over the twenty-four hours, and the load-factor of the plant approaches unity. This condition is highly favourable to the utilisation of the heat-energy of town refuse, which must be burnt at a very regular rate; this process may therefore be profitably combined with those already mentioned. A. H. A.

330. *The Tendency of Central Station Development.* (Elect. World, 30. pp. 673–674, 703–704, & p. 759, 1897.)—These articles describe the developments which have taken place in recent years in the equipment and management of electric central stations. Ten years ago the only two systems of distribution were the continuous-current low-pressure distribution and the high-pressure single-phase alternating-current system with its multiplicity of small house-to-house transformers. The continuous-current system was used where the area of supply was compact, and the alternating-current system for straggling districts. The chief objection to the former is the high price of land and buildings for the station in a densely populated district, and the latter is open to objection on account of the small all-day efficiency of the plant. The consequence is a tendency to generate the power in each case at some distance from the centre of distribution where land is cheap; to transmit at high pressure to sub-stations, where it is transformed by means of large stationary transformers if the supply is to be alternating, or by transformers and rotary converters if a continuous-current supply is desired. The distribution is effected from the sub-stations by means of a low-tension network of conductors. In the central station itself small high-speed dynamos are, for economical reasons,

being replaced by larger low-speed machines, and belt-driven machines are giving way to those coupled direct to the driving engine, so that the latest developments are in favour of the slow-speed direct-coupled dynamos for either railway work, direct-current lighting, or alternating-current work. The development of the low-speed dynamo has been effected by increasing the diameter of the rotating part and by reducing the peripheral speed; thus reducing the iron losses and enabling the induction in the iron to be carried much higher without impairing the efficiency of the machine. A great help in the same direction has been obtained by the use of slot and tunnel armatures in place of smooth-core types, and the consequent permissible diminution of the air-gap.

The types of alternator most generally used now are inductor machines and machines with revolving fields, it being a great advantage to have high-pressure armatures which are stationary and free from mechanical strain. The disadvantage of aiming at a low first cost in erecting a central station is now more recognised, since the poorer the quality of the installation the more attention does it require and the greater are the running expenses and also the annual depreciation; and, as in all other trades, everything which contributes to the minimising of manual labour is now being advocated. W. G. R.

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331. *The Cost of Steam-Power.* **H. A. Foster.** (Amer. Instit. Elect. Engin. 14. pp. 315–345 and 461–470, 1897.)—This is a paper containing details collected by the author on the cost per horse-power hour of steam-power The plants on which tests were made were:—

Two Electric Lighting Stations;
One Grain Elevator;
Three Water-Works Pumping Stations;
Two Flouring Mills;
Six Cotton Mills;
Four Newspaper and Printing Offices;
and four others.

The items included in the cost of production are Fuel; Wages, Supplies; Repairs; Water; Incidentals, including lighting and removal of ashes; and also the fixed charges, Interest on cost of plant, Depreciation on the value of the plant, Insurance, and Taxes. When the cost of an item depends on the locality it is reduced to a certain standard in order to give a fair comparison. In estimating the cost per hour care is taken to reckon only the hours of actual working of the plant. In this way it is estimated that the cost of steam-power per horse-power hour is 0·00824 dollar for an average of 3080 hours. Below is given a table of comparison of this result with those obtained by others.

Comparison of Different Estimates.

Large, Compound Condensing Engines.

	Cost per H.P. hour.
Emery (for 3080 hours)	$·00784
Emery (for 7090 hours)	·00617
Emery (for 3080 hours)	·00856
Webber, 650 H.P. 3080 hours	·00720
Webber, 1050 H.P. 3080 hours	·00646
Hale, 2985 hours	·00557
Main, 3080 hours	·00637
Foster, average, 3080 hours	·00824

The average of all these estimates indicates that the cost per horse-power hour is about $0·00705 or 0·3525 of a penny.

W. G. R.

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332. *Electric Plant of U.S.A. Government Printing Office.* (Elect. World, 31. pp. 94–95 and pp. 115–118, 1898.)—In this very detailed description of the electric plant of the Government printing office at Washington, the great advantages of electric power over steam-power for driving machinery in factories is brought forward. Every piece of machinery in the place is now driven by motors, generally by direct couplings so that the inconvenience of running-belts is avoided. The following table shows the number of motors and the horse-power at present in use:—

	No. of Motors.	Horse-Power.
Crocker-Wheeler motors geared to printing-presses	85	272
Crocker-Wheeler motors keyed to shaft of printing-presses	7	35
Crocker-Wheeler motors direct-coupled to machinery	56	78
Crocker-Wheeler motors belted	14	144
Lundell motors keyed to shaft of presses	2	10
Bullock motors keyed to shaft of presses	2	10
Sprague elevator tandem drum	1	30
Total in daily use at present	167	579

The chief electrician states that the entire power necessary to do all the work of the office at night, including the running of the large web-presses on which the 'Congressional Record' is printed, did not amount, before the introduction of the electric motors, to within 15 or 20 per cent. of the friction load of the press-room engine and shafting. This shows at once one of the great advantages of the electrical transmission over the old belt system. All the motors are supplied with cut-outs, as fuses are regarded as unreliable and dangerous. On one occasion one of the press-men accidentally had his hand caught in the gearing of the press; the load was raised above the normal, the cut-out acted, and his hand was saved. Had a fuse been used instead of a cut-out he would probably have lost his hand. The motors are all controlled by Crocker-Wheeler controllers. W. G. R.

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333. *Electrical Shop Transmission.* **H. G. Dimick.** (West. Electn. 22. pp. 64–65, 1898.)—This article deals with the leading features of electrical transmission of energy in workshops, on the direct-current system at low pressure. The use of electromotors driving line-shafting is recommended rather than separate motors direct-coupled to the machines, unless the latter require more than 5 horse-power each; the generators should be large units, with a reserve, but a small unit should be provided for times of very light load. The apparatus required on the main and distributing switch-boards is briefly described, and the type of distributing cables to be used is considered. Automatic starting rheostats, which return to the starting position with all resistance in the armature circuit, whenever the current ceases to flow or exceeds a safe limit, are regarded as indispensable, and are discussed at some length. The margin of motor capacity to be allowed under given conditions is also considered. A. H. A.

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334. *Transformer Distribution.* (Elect. Runds. 15. pp. 40–42, 1897.)—In spite of their extremely high efficiency at full-load, transformers show a poor all-day efficiency when permanently connected across the mains. Central station experience shows that the total energy delivered by a transformer during 24 hours is approximately equal to the energy delivered by it when worked for two hours at full-load. On this assumption the all-day efficiencies and other data of transformers of different outputs are given by the following table:—

Output of transformer in kilowatts.	Useful energy in kilowatt-hours.	Iron losses in kilowatt-hours.	Copper losses.	Meter losses.	Total energy absorbed.	All-day efficiency.
10	20	3·52	·31	·864	26·694	·75
5	10	3·72	·17	·576	14·466	·692
2·5	5	2·28	·09	·288	7·658	·652
1	2	1·56	·04	·288	3·888	·515

It has been found by Herr Schlatter that when equal numbers of the above four types of transformers were connected across a distributing network, the mean all-day efficiency came out at ·652, which is in accordance with the assuption made above. In order to improve the all-day efficiency, the house-transformer system has been abandoned, and the transformer sub-station system introduced instead; the number of transformers being thereby reduced and their size increased. In order to reduce the losses to their smallest possible extent, it is necessary to keep only as many transformers in circuit as will enable them to work at or near their full-load. Instead of completely switching them off, Herr Schlatter has devised an automatic switch by means of which an auxiliary transformer whose primary and secondary are joined in series with those of the large transformer is thrown into circuit when there is no secondary load, and absorbs the greater part of the losses on open circuit, thereby reducing them by 95 %. The Schlatter switch has already been described in these Abstracts (see No. 196, Feb. 1898). A. H.

335. *The Saving Effected by Large Transformers.* (Elect. Engr. N.Y. 25. pp. 58-59, 1898.)—The distinct economy of using a few large transformers instead of many small ones is here shown by details of plants in which a change from the latter to the former has been effected. In a town in Massachusetts, 57 small transformers have been replaced by 18 larger ones of the latest type. The total core loss of the small ones which supplied 1499 lights was 5866 watts, whereas the large ones supply 1624 lights with a total core loss of only 1348 watts. This is equivalent to saying that the yearly saving of energy is 39,578 kilowatt-hours, or a saving per light capacity per year of 36·2 cents. Other instances are cited to show that where small transformers are installed it is a good commercial investment to replace them by as few larger ones as will meet the requirements of the particular plant.
W. G. R.

336. *Electric Railways.* **G. W. Meyer.** (Elect. Runds. 15. pp. 50-54, 1897; id. 15. pp. 60-63, 1898.)—The author discusses the various methods available for supplying power electrically to trams or railway-locomotives. He advocates the use, for long lines, of the combination of a triphase alternate-current system with a continuous-current system and accumulators. In the power-station high tension triphase alternate currents are generated, and these currents are transmitted to transformer-stations in the neighbourhood of the railway. The transformers consist of drehstrom motors coupled directly to continuous-current generators which supply the current for the continuous-current motors on the cars. In the transformer-stations, accumulators can be connected in parallel with the continuous-current generators, these protecting the machinery and considerably increasing the profits of the plant. This system is due to Herr Uppenborn, and has been introduced at Cassel and Budapest (Elektrotechn. Zeitschr 1893 & 1894). A somewhat similar system, due to Herr Déri

is referred to in which transportable transformers and accumulators are employed. The high-tension triphase-currents are transformed down to lower-potential alternate currents which are supplied to overhead conductors along the line. The cars, etc. are provided both with drehstrom and continuous-current motors. The drehstrom motors are connected to the drehstrom conductors (2 wires, 1 earth) by the usual sliding or rolling contacts; whilst the continuous-current motors, which can also act as generators, are connected to a portable accumulator-battery in the vehicle. The continuous and alternate-current motors are only connected mechanically. The operation is as follows, viz.:—During the normal propulsion of the vehicle, the alternate-current motors drive, any excess energy being stored in the accumulators by means of the continuous-current machines. On gradients, where the alternate current is not sufficient for driving the vehicle, the accumulator-battery discharges into the continuous-current machines which now serve as motors. In parts of the line where it is not possible to supply current to the vehicle from the lines, the battery current alone serves for propulsion.

Various other systems of this kind are described and illustrated, viz.: that of R. Arno, in which a simple alternating current from the line drives an idle-running synchronous motor on the car, which motor, by the reaction of the alternate current generated in its armature on the alternating field, serves to produce a resultant rotary field of constant strength as in polyphase motors. This field replaces the rotary magnet-pole of a polyphase generator. Therefore, by arranging coils as in these generators, a two- or three-phase current can be obtained. The stationary part of the synchronous motor is thus, at the same time, the field for the production of the rotary field, and the armature for the polyphase current produced. The said polyphase current serves for driving one or more asynchronous motors geared to the driving-wheels of the vehicle. This system is, however, expensive and complicated. A somewhat similar system due to the Union-Elektrizitäts-Gesellschaft is also described, but this is open to the same objections as that previously indicated.

The systems of C. F. Scott and others having been described, the author ends by stating that continuous currents should be used for short lines; for longer lines the drehstrom-continuous current transformer system, or Déri's, or, where this also is impossible, the simple alternate current converted into a polyphase current (drehstrom). He also recommends an electrolytically-rectified (Pollak-Graetz) or mechanically-rectified alternate-current system in combination with stationary or portable accumulators.

C. K. F.

337. *Electric Locomotive.* (Elect. Runds. 15. pp. 79–81, 1898.)—The article contains an illustrated description of an electric locomotive for shunting purposes, built by the Allgemeine Elektrizitäts-Gesellschaft of Berlin. A. H.

338. *Electric Railway of the* 1900 *Exhibition at Paris.* **J. Reyval.** (Écl. Électr. 4. pp. 191-204, 1898.)—Although the conditions laid down by the Commissioners in their specification for the Electric Railway for the Paris Exhibition are somewhat severe, five competitors submitted schemes for the carrying out of the project. Of these schemes, that of Blot, Guyenet and Mocomble is the most interesting and attractive. Taking the idea from the railway at the Chicago Exhibition, they propose having the carriages fixed to the platforms, while the latter are themselves movable. Their system includes the following:—

First. A first platform moving at the rate of 10 kilometres an hour, having a breadth of 1·3 metres, and rolling on rails 90 centimetres apart.

Second. A second platform moving at a rate of 5 kilometres an hour, having a breadth of 80 centimetres, and rolling on rails 45 centimetres apart, and serving as a terminus.

Third. A fixed platform 90 centimetres broad.

Fourth. A metallic foot-bridge supported by columns and serving to support the rails.

Fifth. A staircase serving as an entrance and an exit for the passengers.

The platform which moves at the rate of 5 kilometres an hour is to be placed between the fixed platform and that moving at the rate of 10 kilometres; and the whole railway will form a closed circuit about 4200 metres long.

The system of two movable platforms permits of a large number of people being rapidly carried: it is calculated that this particular railway will be able to carry 38,880 passengers an hour.

W. G. R.

339. *Demeuse Surface Contact Traction System.* **E. Piérard.** (Électricien, 15. pp. 35–38, 1898.)—It is stated that this system is characterised by a great simplicity, strength, and relatively low cost. The system consists essentially of a number of metallic button contacts placed along the track, each contact being connected to an automatic distributor, contained in a simple square cast-iron box imbedded in concrete, fitted with a cover through which the contact passes and to which it is rigidly fixed. The distributor consists of an electromagnet with two bobbins, one wound with fine wire and the other with thick wire. The car carries a small battery of accumulators. When the switch is closed on the car, the connections are so arranged that the fine wire coil is momentarily magnetised by the accumulators, and attracts an armature consisting of a lever at the end of which are blocks of copper or carbon for making contact in an upper or lower fork of special construction. The moment the fine wire coil is magnetised the lever is raised; the lever breaks contact at the lower fork, thus breaking the shunt coil, but having at the same moment made contact at the top fork, and thus completed the motor-circuit and magnetised the thick wire coil. Under these conditions the motor

will start, and as the car runs along its slider will break circuit with the leaving contact, and the next contact will come into operation, and so on. The sliders have received special attention to obviate wear and noise, and consist of five to ten strips of steel 5 cm. high and 0·5 cm. thick separated 0·5 mm. to 1 cm. from one another by means of lead washers. The use of an independent distributor for each section of the track allows the cars to be run in either direction by simply reversing the armature connections of the motor. This system also allows cars to follow one another as close as is desired on the same track.

According to the inventor's estimate the equipment of a kilometre of single track would amount at Brussels to about 27,000 francs, and a kilometre of double track to 50,000 francs, which amounts are comparable to an overhead trolley system. The author suggests that by the use of a double row of contacts it would not be difficult to work on the three-phase system, each row of contacts corresponding to one phase and the rails to the third. This system would have the advantage of not disturbing telephone installations. L. J. S.

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340. *Rapid Electric Traction.* **C. H. Davis** and **F. S. Williamson.** (Eng. Mag. 14. pp. 32–55 & 253–266.)—The authors consider the possibility of travelling from Philadelphia to New York, a distance of 85 miles, in 36 minutes, involving a speed of 170 miles per hour. A third rail system is suggested with 11 high-tension generating stations along the line and 30 rotary-transformer sub-stations. The track should be rigid, with rails of about 250 lbs. per yard, so as to avoid the creation of destructive waves. To reduce oscillation one rail might be raised somewhat above the level of the other. On the sharpest curve (of 4 mile radius) the elevation of the outer rail would not exceed 3·5 inches. A system of automatic signalling is described such that the power is shut off when the signal is at danger, rendering it possible to run trains with a headway of 3 minutes. The proposed motor-cars are 150 tons in weight and are carried on two six-wheel bogie trucks.—In estimating the necessary tractive force, the authors assume that the lowest value so far observed for journal and rolling friction would not be exceeded. This would amount to 2·7 lbs. per ton for the car suggested. The greatest curve-resistance would be 1/9 lb. per ton. Atmospheric, oscillatory, and concussion resistances cannot be well computed for want of data: at high speeds the usual formulæ probably give a result much too high. The authors consider that a train of five cars will not require more than 10,000 H.P. at the station under economical conditions, the maximum being about fifty per cent. greater. The generating stations would have an economical capacity of 30,000 H.P., and the sub-stations 20,000 H.P.

The total cost of construction and equipment is estimated at £38,000,000. The expenses per car mile will probably closely approximate to present practice, for, while fuel and some other items will be increased, the saving in the labour account will be far greater owing to the high speed and omission of local stations. A detailed estimate, by comparison with the expenses per car mile as obtained under ordinary steam railway-conditions, leads to the conclusion that the saving due to the proposed system would balance the additional expenses. The cost per train mile on a steam road may be taken as 2*s*. 6*d*.: or, considering a train of four cars, and regarding the locomotive as equivalent to one car, the cost per car mile under these circumstances amounts to 6*d*. Assuming the cost per car mile to be 7½*d*. (*i. e.* twenty-five per cent. greater than with steam), the total operating expenses for 500 trains per day (averaging 2·8 cars each) amounts to £1,303,050 per annum. The capital is put at £20,000,000 of three per cent. gold bonds running for 100 years; £20,000,000 of non-cumulative four per cent. stock and £20,000,000 common stock. The fixed charges would thus be £750,000. A four per cent. dividend on the preference amounts to £800,000. Assuming 73,000,000 passengers per annum at 10*d*., the gross receipts amount to £2,920,000. Thus we have:—

Gross receipts	£2,920,000	$14,600,000	100 %
Operating expenses ..	1,303,050	6,515,250	44·6 %
Fixed charges	750,000	3,750,000	25·6 %
Profits	866,950	4,334,750	29·8 %

Judging by present traffic statistics, and taking into consideration that traffic is always increased by electric traction coupled with such a large reduction in the fare (viz., 1 to 10), it may be reasonably supposed that the number of passengers travelling would largely exceed the number here given, thus ensuring a financial success. W. R. C.

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341. *Electric Traction on Railways.* **F. J. Sprague.** (Eng. Mag. 14. pp. 752–757, 1898.)—The author continues the discussion of the application of the system of individual car equipment to railway service. Controlling devices, signalling systems, and automatic electric brakes are briefly touched on, and the use of local storage batteries having high rates of charge and discharge is recommended for equalising the load on the generators; these may be used in conjunction with rotary converters and multiphase transmission. The Buffalo Street Railway Company, paying for supply from Niagara on the basis of maximum demand, find the cost to be greater than that of steam power; this would probably not be the case if storage were made use of.

The conditions of passenger traffic on short and long lines respectively are essentially different; the former require a frequent service of trains, while the latter can only be profitably operated by means of heavy trains at long intervals; hence electric traction is well adapted for use on short lines, but is unsuitable for long distances. The capital cost of an electric railway exceeds that of a steam railway by the amount expended on the generating and transforming stations; so that, unless the running costs are materially reduced or the traffic increased by the adoption of electric traction, no advantage is gained.

The author concludes that:—the construction and working of main line electric railways present no insuperable difficulties; urban and suburban railways and busy branch lines are especially suited to electric traction; individual car equipment is preferable in the above cases; the use of storage batteries is of great importance, and will be extended; and the use of water-power is not necessarily advantageous. A. H. A.

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342. *Loss in Stoppages of Electric Cars.* **H. S. Hering.** (Amer. Electn. 9. pp. 286–287, 1897.)—As the result of tests, the author finds the difference between making a stop and start at a station and running past it varies from 75 to 100 watt-hours, depending upon the gradient and load. The average value under ordinary conditions for a partially loaded 7½ ton car is 85 watt-hours. Assuming the cost of electrical energy to be 1 cent per kilowatt-hour, one stop would cost ·085 cent, and the cost of making one unnecessary stop on each trip for fifteen trips daily would amount to $4·67 per car per year, and for 100 cars $467 per year for the one extra stop per trip. About 74 per cent. of the total energy required for propulsion is expended in accelerating and lifting a car, showing that if only one half of the energy stored in a moving car could be saved, the saving would be very large. As much as 20 per cent. may generally be saved by careful driving; 10 per cent. might be easily effected. Taking the average performance in city running on a 10-mile, fifteen-car, fifteen trip road as 1300 watt-hours per car mile, a 10 per cent. saving amounts to $1067 per annum. A motor-man should use the brakes as little as possible and drift as much as possible. W. R. C.

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343. *Electric Car Driving.* **W. Munroe.** (Amer. Electn. 9. pp. 320–321, 1897.)—The author calls attention to the waste of current caused by careless driving. In order to maintain schedule time, motor-men frequently rush the controller handle round at starting without stopping at intermediate points. A heavy current is consequently taken without any large decrease in the running time. Comparative runs made upon a line with, in the one case, an average good motor-man and, in the other case, the electrician's assistant handling the controller, showed a difference of 20 per cent. in the watt-hours in favour of the assistant. Waste is also caused by seeking to increase the speed by weakening the field in any case where the car cannot attain a reasonable speed; the method is all right on the level but not on a gradient, as only a low back-E.M.F. can result on the latter. It sometimes happens that motors heat more than would be expected, and armatures burn out just when there is heavy traffic and it is most inconvenient. This is often due to excessive lowering of the pressure

on certain parts of the line necessitating the use of abnormally large currents. To detect such parts of a road it is advisable to run a car with a voltmeter and ammeter upon it, taking frequent observations during the trip. W. R. C.

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344. *Sprague Multiple-Unit Traction System.* (Amer. Electn. 9. pp. 343–344, 1897.)—On July 26th, 1897, the first public exhibition was given of Mr. Frank J. Sprague's new multiple-unit electric railway system, a trial train of six 42 ft. elevated railway-cars being run over the tracks of the General Electric Co. of Schenectady, N.Y. The cars used are to form part of the equipment of the Chicago South Side Elevated Railway. The main idea of the Sprague system is that it provides means for the individualising of cars, and yet admits of their being concentrated in trains without detriment to either method of operation. Each car is complete as it runs, yet if half a dozen of them are thrown together they lock-step at once and the train operates as a unit. Each car at Schenectady was equipped with two G.-E. 57 motors rated at 50 H.P. each.—The Sprague controlling system is similar in some respects to that employed with the Sprague electric elevators, the controller being operated by means of a small pilot motor. The motor-man may control the train from either of the platforms of any one of the cars; the controllers on each car having simultaneous motion corresponding to each movement of the handle operated by the motor-man. Underneath each car runs a flexible cable equipped with a peculiar interlocking coupling so that, no matter what is the speed, any car can be almost instantly thrown in or detached, in the former case at once answering to the control of the train motor-man. At Schenectady additional cars were coupled to a train running at 25 miles per hour.—The system includes automatic devices similar to those on the Sprague electric elevators, whereby every contingency that may arise in operation is provided for, such as burnt-out motors, defects in motor controllers, breaking of any of the circuits, etc. The whole train of cars at Schenectady was run at 33 miles an hour, and then split up into various groups of its component parts, making again the same rate of speed. The passengers on board gave an approximation to the normal conditions of an ordinary train load. Each car had air-brakes and an automatic air-compressor, circuit-breaker and electric lights, all drawing their supply from the main-line circuit, which in this instance was carried by an outer rail.

The important points in the Sprague system are the subdivision of traffic of which it admits, and a maximum tractive power which enables a maximum accelerating effect to be obtained. About 58 per cent. of the weight of the train and its load is available for traction, and the weight is moreover distributed in an ideal manner over the rails. There is, further, a saving of time to passengers in running a single car in light hours. L. J. S.

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345. *Single-Motor Cars.* (Amer. Electn. 9. pp. 360–361, 1897.) —The author discusses the cases where a single equipment is much superior to a double one. This is specially so in the case of interurban service. The series-parallel controller with its two motors may be said to have practically displaced the single equipment for street railway-work. On long interurban lines, where but few stops are made, there is practically but one speed, and a single running-notch suffices, although single equipments have been made with two and sometimes three running-notches. A single equipment will take less current than a double equipment of the same capacity, owing to the fact that one large motor has a higher efficiency than two small ones. Further, in the case of a double equipment it is very rare that the motors act together: one is almost certain to take more current than the other, and it is easily possible for one motor to be heavily overloaded and the other lightly loaded. Apart from these poor efficiency conditions, the power wasted in skidding of the wheels greatly detracts from the output of the double equipment in miles per kilowatt-hour, and gives the single equipment another point of vantage. A good illustration of how a single equipment can do more work in proportion than a double one often obtains in the case of hill climbing. The chief objection to a single equipment is the uneconomical variation of speed, and with the most usual conditions under which a street railway works it is an insurmountable one. The control is simply a rheostat in series with the motor, and unless the rheostat is heavily built with thick wire this provides but one running-notch, for the reason that if the rheostat is not immediately cut out it will overheat. A second running-notch can be provided by feeding the current into the motor at some point in the field-winding. Usually this place cuts out about half of the winding, thus weakening the field and increasing the speed of the motor. The speed is also increased owing to the fact that the drop over the field magnets is lower, and consequently the voltage across the armature is greater. The usual methods of connecting a single equipment is to utilise a portion of the contacts of a series-parallel controller; it is, however, not economical to do so, for the reason that the same thing can be accomplished with a much less expensive device. An illustration is given of the T-H method of connecting a single equipment and the connections thereof. The old Sprague method of controlling a motor by the commutated-field device—that is, a subdivision of the field-coils into sections, and the excitation of these sections by connecting them in series or multiple with one another—provides a great many more running-notches; but the difference in speed between these notches is not so marked as to make it worth while to employ the method, except in special cases. The motor-man who is running a single equipment should learn the art of drifting where a reduced speed has to be maintained; this is accomplished, when rheostatic control is used, by turning the full power on for an interval and, as soon as the car has gained headway, cutting it

off altogether and allowing the car to drift along. The car should be drifted as much as possible, and the brake used as little as possible. L. J. S.

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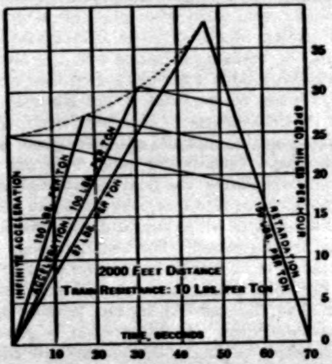
346. *Electric Traction.* (Amer. Instit. Elect. Engin. 14, pp. 453–460, 1897.)—This is a discussion upon a paper by **Gerry. Dr. Perrine** called attention to the importance of rapid acceleration in train service. The **President** said that electricity afforded a means of running trains at always the same headway, thus giving a more popular service, the periods of light load being met by the use of shorter (not less frequent) trains. **Prof. Thomson** remarked that although it was desirable to apply the power to motors on every car, it was questionable whether the gain was sufficient to warrant the increased outlay and the use of complicated mechanism.

Mr. Steinmetz gave some interesting figures with regard to the elevated railroad. Here, the distances between stations being short, the motors never run at full speed; each run consisting of acceleration and retardation. The case is considered of a 2000 feet run in 70 sec. The train-resistance being taken as 10 lbs. per ton, the accelerating-effort as 100 lbs. per ton, and braking-effort as 150 lbs. per ton, a curve is obtained, shown in the figure. The train accelerates for 31 sec., reaching a maximum speed of 30·5 miles per hour; it then coasts, the power being turned off, up to $52\frac{1}{2}$ sec. after the start, after which point the brakes are applied until the train is brought to rest. The lowest acceleration at which the distance can be covered in schedule time is 87 lbs. per ton. With this value, as seen by the curve, there are only periods of acceleration and braking, the maximum speed rising to 38·2 miles per hour. The more rapid the acceleration, the shorter is the time required for accelerating, leaving more for



coasting, and at the same time the maximum speed decreases to 30·5 miles at 100 lbs. acceleration, 27·2 miles at 150 lbs., and 24·8 miles in the theoretical case of infinite acceleration—*i. e.*, if the train could be brought up to maximum speed instantly. These figures have an interesting bearing upon the energy consumed. With change of acceleration the speed varies from 24·8 to 38·2 miles per hour—*i. e.* in the proportion of 1 to 1·54, and consequently the kinetic energy in the proportion of 1 to 2·4. The energy put into the train for acceleration varies even more, because at the lower acceleration the time of acceleration is greater, and thus the friction loss during that time is also greater. Since the energy put into the train, up to the point of maximum speed, equals the total energy required to cover the distance in schedule time, it follows that by varying the rate of acceleration the energy consumed can be varied in the ratio of 1 to more than 2·4; thus with the slowest possible acceleration more than 2½ times as much energy is required than would be necessary at infinitely rapid acceleration—*i. e.* the greater the acceleration the less energy required to cover the distance in schedule time, but the power absorbed by the motors is larger during the time they are in operation.

A lower maximum speed may be employed with a given acceleration and retardation by running partly at constant speed, but the efficiency is considerably less than when coasting is taken advantage of, as may be seen thus:—The total input of energy is equal to that consumed by the brakes plus that consumed by friction. The latter is the same in any case, but the former is less in the case of coasting, the brakes being applied at a lower speed than when running at constant speed. Thus it is theoretically (also practically) uneconomical to leave the motor in circuit after the period of acceleration has passed.

During the whole time of constant acceleration, part of the voltage is consumed in the rheostat, since without a rheostat a series motor does not maintain constant torque at constant voltage with varying speed. Such loss may be partly reduced by cutting out the rheostat somewhat before the maximum speed is reached, and allowing the motor to accelerate with an effort decreasing with the speed, as indicated by the dotted curve in the figure. The permissible range, however, is very short.

With regard to subdivision of motors, Mr. Steinmetz did not think it necessary to have all axles driving. The limit of permissible acceleration is not determined by the adhesion of the wheels, but by the comfort of the passengers. W. R. C.

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347. *Electric Traction.* **C. Marshall.** (Elect. World, 30. pp. 760–761, 1897.)—The author deals generally with electric traction, and enumerates the advantages likely to follow by its adoption on present steam roads. The coal consumption in locomotives varies from 3½ to 10 lbs. per H.P. hour, which allows a

large saving to be effected by the use of electricity generated at suitably placed central stations. A change to electric traction also generally means a large increase in traffic, as on the Berlin and Hartford (U.S.A.) line, where the increase amounted to 400 per cent. The greatest difficulty lies in the comparatively low voltage that must be employed, and consequent large expenditure of copper. According to Stillwell it costs 400 times as much copper to transmit a horse-power ten miles at 500 volts as it does at 10,000 volts. W. R. C.

348. *Overhead Trolley Construction.* (Electn. 40. p. 379, 1898.) —A short illustrated account is given of the "Wood" type of frog for crossings and turn-outs. The flanges of the trolley-wheel are guided in the desired direction by grooves cut in the lower surface of the frog; in some cases a movable point is provided similar to that on the rails. These frogs are in use on the Bristol electric tramways. A. H. A.

349. *The Rouen Electrical Installation.* **J. Reyval.** (Écl. Électr. 13. pp. 585–589, 1897.)—The first electric plant at Rouen was installed in 1880 to light the quays. The increasing demand for artificial light has resulted in the erection of a large and well-equipped central station for the generation and distribution of electrical energy by both continuous and alternating currents. To meet the requirements of the consumers, three groups of dynamos have been installed:—First, two pairs of Brown dynamos giving 1200 amperes each at 120 volts, which are coupled two and two in series to distribute at 240 volts. Second, two Thury dynamos driven by a 1000 horse-power Carel engine: these dynamos have ten poles and have carbon brushes, their normal output being 2050 amperes at 125 volts, and when coupled in series provide current at 250 volts for distribution; another similar group is shortly to be installed. Third, four Alioth converters, each coupled to a Willans machine. These converters have a double armature winding, and can furnish simultaneously continuous and alternating current or convert continuous current into alternating current, or *vice versa.* The alternating current is transmitted by underground cables at 2000 volts and distributed by overhead wires at 180 volts. The distribution of the continuous currents is also effected by overhead wires. The starting current for the converters is supplied by accumulators. In connection with the central station is a laboratory for the calibration and adjustment of electricity meters; the regulation and cleaning of the public arc-lamps; the measurement of the candle-powers and efficiencies of incandescent lamps; and for performing all electrical measurements likely to arise in connection with a central station.

W. G. R.

350. *The Price of Electrical Energy.* **G. Claude.** (Écl. Électr. 14. pp. 93–99, 1898.)—This is a paper on sliding scales in the price of electrical energy, particular attention being given to the Brown and Routin system. It is pointed out that it is unfair to charge the same per kilowatt-hour at all times and to everybody, and that the charges should be made with certain stated objects in view. It is not so desirable that the maximum rate of consumption of energy should be great, as it is that the average rate should be high. The ratio of the average rate to the maximum rate of consumption is called the coefficient of consumption. Charges should therefore be made so as to entice consumers to increase their coefficient of consumption without, at the same time, necessarily increasing their maximum rate; also to tempt them to use more energy during the day, when the load on the central station is moderately light; and, further, to diminish the price according as the coefficient of consumption increases. Brown and Routin have endeavoured to attain these objects by charging at a higher rate in the evening than during the day, and this without using two meters. One meter is regulated by a clock arrangement, so that during certain hours of daylight its rate of registering is only half the rate during the remainder of the twenty-four hours for the same rate of consumption of energy. Being regulated by a clock, the control is automatic, and no separate circuit is required since that regulating device is worked by alternating currents when the current in the mains is continuous, and by continuous current when the supply is alternating. The regulating current can therefore be sent through the transmission-mains, and the controlling clock-work placed at the central station. W. G. R.

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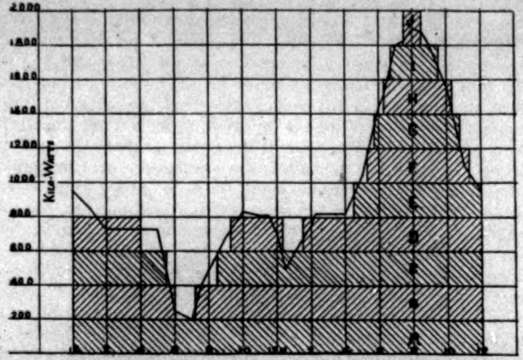
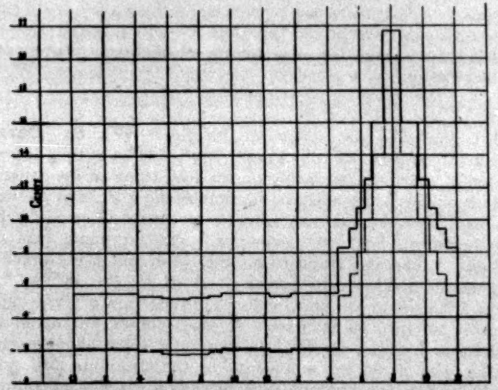
351. *Charging for Electrical Energy.* **W. S. Barstow.** (Elect. Engr. N.Y. 25. pp. 49–51, 1898.)—The author describes a system of charging depending on the load curve of the generating-station, which is intended to be simple and just, and to improve the load-factor by degrees. The cost of electrical energy is divided into operating and fixed expenses. The minimum load on the station is taken as a standard or unit load, and the average load-diagram is divided into blocks as A, B, C, &c. in Fig. 1, each equal in height to the unit load; the proportion of fixed expenses per day assigned to each unit of plant (of output equal to the unit load) is found by dividing the total fixed expenses per day by the ratio of the maximum load to the minimum load, and the fixed expenses per hour of each block are given by dividing this quotient by the length in hours of the block in question. The average value of the fixed expenses per unit load per hour at each hour is then plotted, as shown by the dotted line in Fig. 2. The quotient of the operating expenses per annum divided by the number of kilowatt-hours generated, corrected for the mechanical efficiency of the plant at different loads, gives the operating

Fig. 1.—Average load curve.



expenses per unit generated. This value, expressed in terms of the unit load for one hour, is added to the fixed expense per unit load per hour at each hour, giving the full line curve in Fig. 2 for the

Fig. 2.—Average expense curve.

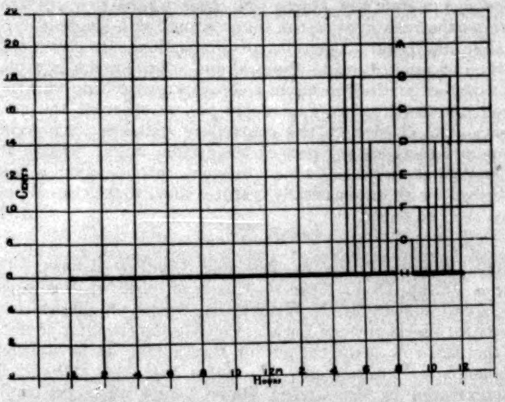


Dotted line shows fixed expenses. Solid line shows total expenses.

total expense per unit load per hour. It will be seen that as the load factor improves, the total expense line falls towards the level of the lowest total expense, or the low-cost period is lengthened, and the high-cost period shortened. It is suggested that the day be divided into two parts, and that the average low rate be charged between the hours indicated by the curve; the effect of this is shown in Fig. 3. The Kapp meter device, in which a self-winding clock is used, is recommended for the purpose of changing over from one meter to another, or for substituting one recording train for another, and *vice versa*, at the hours chosen; so that energy consumed during the time of light load may be charged for at a lower rate than that used during the time of heavy load.

A. H. A.

Fig. 3.—Total expense curve.



Effect on total expenses of increase of load factor; *i. e.*, A, load factor, 45 per cent.; B, load factor, 50 per cent.; C, load factor, 55 per cent.; H, load factor, 100 per cent.

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352. *Multiple Rate Metering.* **E. Oxley.** (Elect. Engr. N. Y. 25. pp. 51–55, 1898.)—The importance of improving the form of the load curve of generating-stations is explained, and the method of effecting this object by charging a lower rate for energy during the period of light load than during the period of heavy load is advocated. Separate meters for the two periods, thrown into action at stated times by means of a clock mechanism, are objected to on the score of expense and want of reliability; the system of controlling the shunts of meters by means of a separate wire from the generating-station, so as to vary the speed of the meters, is also open to objection, since the drop of pressure in the controlling wire introduces errors, and the interruption of the wire would cause all the meters to stop. An apparatus is described for use with either two meters or one at each point supplied, by

means of which the differential rate may be applied, with direct control from the station. At each point a controlling switch is placed, actuated by two high resistance electromagnets; the connections of the latter are such, that upon earthing one or other of the mains at the station the corresponding electromagnet of each controller is energised, and throws a switch which either stops one meter and starts the other where two are used, or changes the resistance in the shunt circuit of a single meter so as to alter its speed. Diagrams of connections are given, and the method of application to chemical and other meters is explained. By using an earth-connection, a separate controlling-wire is rendered unnecessary, but apparently one or other of the mains is always earthed through the controlling switches. An accidental temporary earth on any part of the system might actuate all the controllers at the wrong time; to meet this objection, a device is described which automatically restores them to the correct position after such an event. A. H. A.

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353. *Relative Values of* 220 *and* 110-*Volt Lamps*. (Elect. Runds. 15. pp. 75–77, 1898.)—This is an abstract of a paper on the above subject by F. W. Willcox, recently published in 'The Electrical World of New York.' Considering the inferior efficiency of the 220-volt lamp, the author thinks that its advantages are frequently over-estimated. He states that the 220-volt lamps manufactured in the United States take 4 watts per candle as against 3·1 and 3·6 for 110-volt lamps. Hence, although there is a saving in copper by using a 220-volt system, the capital expenditure on the generating plant is increased. Under certain conditions, therefore, it would be better to use 110-volts. The author then considers in detail 110-volt two and three-wire systems as against 220-volt systems. A. H.

TELEGRAPHY AND TELEPHONY.

354. *Synchronograph Tests.* **A. C. Crehore** and **G. O. Squier.** (Elect. World N. Y. 31. pp. 145–147, 1898.)—This is an account of tests of the synchronograph on the English telegraph lines. The longest loop tried was 1097 miles, from London to Glasgow, Aberdeen, Edinburgh, and return to London by a different pole-line. The synchronograph was tried with a Wheatstone receiver, and it responded readily to each wave of current without any alteration of the receiver whatever. Using the synchronograph with the Wheatstone receiver appears to considerably increase the number of words which can be transmitted, the actual increase in any particular case depending upon the constants of the line. W. G. R.

355. *Hertz Telegraphy.* **G. W. Selby.** (Electn. 40. pp. 397–398, 1898.)—A description is given of methods employed by the author during the past four years while experimenting with Hertz telegraphy. He follows closely on the early coherer work of Lodge. Carbon granules appear too sensitive to mechanical and acoustical disturbances for electrical coherers. The coherer preferred consists of a piece of hard fibre with a small hole bored through it, in which are fitted metal pole-pieces of silver wire. The best results are obtained with nickel and steel filings, with a trace of silver wire or mercury. R. A.